THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.
BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Canada, Cuba and Mexico....$3.00 a year.
Foreign subscription ....$6.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

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Entered at the New York Post-Office as Second Class mail matter.

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Of this issue of THE ENGINEERING RECORD 12,000 copies are printed. Total circulation for 1906 to date 408,000 copies, an average of 12,750 copies per week.

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Tensile Tests of Punched and Riveted Angles and Plates.

In another column of this issue of The Engineering Record there will be found an interesting paper by Prof. Frank P. McKibben, on "Tension Tests of Steel Angles with Various Types of End Connections." The purposes of these tests are set forth in the article describing them and the results throw much light upon the action of angles performing duty under conditions similar to those found in the tests. It may, however, be said of this set of experiments, as of every other set of a similar kind ever made, that they are not sufficiently extensive to settle conclusively a number of questions that arise in the mind of a structural designer in arranging a large class of details involving the connections of plates and angles. Such experiments become expensive when widely extended, and every structural engineer will regard as valuable any contribution of information which aids him, however little, in answering troublesome questions.

Probably no thoughtful bridge designer since the days when angles and plates were first combined in construction has ever been completely satisfied with the detail where two such pieces are connected with rivets. This is not saying that he has not used with confidence justified by experience, certain safe rules or operations by which a suitable amount and distribution of material has been reached; but on the other hand, it is beyond dispute that he has not been able, and is not now, to state with any satisfactory degree of definition just what each main piece of the detail is doing, to say nothing about the distribution of stress in the materials of such details. The full section of an angle is counted as available when under compression, although one leg only may be held at the ends by a sufficient number of rivets. Again, an angle tension member is counted upon as equal in value to its full net section, as if the stress which it carries were uniformly distributed over that section. As a matter of fact, it is perfectly obvious in both cases that the assumptions fundamental to the design involve substantial errors, although not large enough to endanger the safety of the members. It has usually been supposed that if both legs of the angle are connected to the adjacent members all doubt disappears, although a careful consideration of the conditions in such a connection show that there still remains much uncertainty as to the exact value of the joint as a whole. This latter view is confirmed by the results of the tests under consideration. It is not altogether satisfactory to find that the lug at the end of an angle member adds but about 5 to 9 per cent. to the ultimate resistance per square inch.

About 75 to 85 per cent. only of the full resistance of the material was developed in the material tested, even by the use of lugs and of locating the center line of pull through the center of gravity of the rivet holes. This is not a very satisfactory showing, although it should be remembered that these tests were in tension only. It does not appear that if a surplus of rivets had been used these percentages of efficiency, so to speak, would have been any higher. In fact, the manner of failure of the various test pieces appears to indicate that the number and location of the rivets were about as well considered as possible.

There have been some tension tests of plates to determine the effect of rivet holes punched on zig-zag lines as compared with the tests of plates punched with rivet holes on a line at right angles to the line of pull, but these tests have not been sufficiently extended to throw any more complete light upon that class of problems than have the results of tests so far made upon angle connections with plates illuminated those under discussion. All these tests, however, point clearly in one direction, that neither the full compressive resistance of angles in compression nor the full tensile resistance of the net section can possibly be developed with the usual rivet connection details, however well they may be devised or with whatever degree of excellence the work of construction may be done. This is simply another way of saying that there should be a decreased working stress prescribed in such members corresponding to the decreased ultimate carrying capacity as shown by such tests as those described by Prof. McKibben. This has sometimes been done, and any extension of experimental knowledge in this special field of structural design will undoubtedly show that this discount of resistance, so to speak, should always be recognized.

Commercial Factors in Power Plant Design.

The engineer is sometimes supposed to be a person who deals simply with mechanical energy and with its various transformations in the service of man. While he is concerned perhaps primarily with problems which relate to energy transformations, it remains a fact that in no problem which has any relation to conditions in the industrial world can he neglect the general financial or commercial considerations which enter into such problems and which must always exercise the final determining influence in the solution of the problem. If this journal may venture to give advice on such matters, it is to urge all engineers, as they begin the practical exercise of their profession, to study business methods and operations, with prices and values, and, in general, the business point of view in its application to engineering problems.

From the standpoint of energy alone, that machine or process is the most efficient which with a given input of energy will provide the largest output measured either in terms of energy or material substance fashioned to suit some demand of modern civilization. From the broad industrial standpoint, however, this is by no means the ideal or even the desirable. The final test of efficiency is the production of some article of industry or commerce, under such terms as shall make it exchangeable with other products of industry or with any standard of value, under the most advantageous conditions. This seems like a commonplace, but its truth and force are too often overlooked by those concerned with industrial work. When this view point is reached, it is seen to comprise mechanical or energy efficiency as a single item or factor taking its place among others and of no more or less importance than its fellows. This higher definition of efficiency is therefore seen to be not a sacrifice of the mechanical to the commercial, or the scientific to the financial, but rather their inclusion in the higher law which regulates the exchange of values in the world of industry. Energy is rarely an end in itself; no more are the raw materials of nature, and no more is wealth as represented by the mere pile of gold or tokens of value. Civilization is made up of barter and exchange, and each desires to exchange whatever he may have or produce on the most advantageous possible terms with his neighbors. If, therefore, he is occupied with industry, his aim must be not to produce his finished product with the smallest input of energy, not necessarily to use boilers and engines or electrical machinery of the highest possible efficiency; but rather to select such a combination of items of equipment as shall enable him to produce his final product at such expenditure as shall insure its exchange for other commodities on the most advantageous terms.

Applied to power plant practice this means that the aim must be the production of the unit of power for the lowest ultimate cost, including all items properly chargeable to the power house account. Without undertaking any detailed analysis of such accounts, it will be sufficient to note that these items must include (1) labor, (2) fuel, (3) supplies, (4) repairs and maintenance, (5) depreciation, (6) insurance, (7) interest, (8) taxes, and perhaps (9) administration The actual problem in the form usually presented to the engineer involves a choice between certain items of equipment which will affect the relative values of these various items, involving in particular a comparison between those which represent on the one hand the decrease in cost due to higher mechanical or thermal or electrical efficiency, and on the other the increase in fixed charges, maintenance, and depreciation due to higher initial investment, greater complexity, and other causes. The question may arise, for example, regarding the use of condensing or non-condensing engines, or on the use of simple, compound or triple expansion, or on the installation of feed-water heaters, economizers or superheaters. In any such case the problem must be considered under two principal heads: First, what will be the result on those items of the total cost which depend directly on engineering considerations; as for example, what saving in fuel will result from the proposed change in boilers or engines? Second, what will be the price in terms of the remaining items of the total cost which must be paid for this improvement in engineering efficiency?

Thus, for example, a given plant is developing power for 1.5 lb. coal per horse-power-hour. By suitable changes it will be perfectly possible to reduce this expense to, say, 1.2 lb. per horse-power-hour. This will result in a certain reduction in the fuel cost and may react also on the labor. The next question will then be, how much must be paid in terms of the remaining items of total cost for this saving of 20 per cent in fuel? So long as the resulting increase is less than the saving effected, the proposed change will produce an ultimate saving in total cost, and is therefore justified. At the point where the resulting increase is just equal to the saving effected, we shall find the conditions for minimum cost of power, so far as the particular items involved in the question are concerned. Beyond the point where the resulting increase is greater than the saving effected, the total cost will be increased and the conditions will not justify the change proposed. The important point here is that so far as the items under consideration are concerned, the minimum total cost will correspond to the condition where the rate of decrease in one set of costs is exactly equal to the rate of increase in the other; and if we therefore seek to realize minimum total cost conditions, they must be sought where the saving due, for example, to a slight increase in mechanical or thermal or electrical efficiency is just equal to the consequent increase in the remaining items of the total cost.

These principles may be illustrated graphically by laying down a curve representing in a general way the decreasing values of the fuel costs for a given variation in the character of the installation, while on the same axes is plotted the curve of increasing values for the remaining items, including interest, taxes, depreciation, maintenance, and similar expenses. As a rule both of these curves will be convex to the axis of varying conditions; at least one of them will be in all ordinary problems. Examination of two such curves will then show that for those conditions where the slope of the former curve is greater than that of the latter (the two slopes being in opposite directions) any decrease in fuel costs will result in a decreased total, while for those conditions where the slope of the fuel costs is the smaller, any decrease in these costs will result in an increase in the total cost. Between these two sets of conditions is found the point where the slope of the two curves is equal and opposite in direction, and at this point will be found the smallest value of the sum of the two sets of costs, or the lowest total cost.

These general principles, representing what is often known as "Kelvin's law," are applicable to a wide range of engineering problems. In application the principal difficulty arises from the fact that the changing conditions are often highly discontinuous rather than continuous, and that it is often difficult to assign proper values to the resulting changes in the various constituents of the total cost. Thus, the change from non-condensing to condensing engines is not a continuous change but a sudden jump; so likewise is the change from no feed-water heater to full feed-water heater provision. The fundamental principles, however, remain unchanged, pointing the way to a systematic and intelligent study of such problems; and even if the application may be difficult, nevertheless a result reached in the light of such aid as this law or its principles may afford, is likely to be far more trustworthy than guess work in disregard of such aid. In any event we may be sure, when all possible effort has been made to develop the facts and these latter have been marshalled and studied by the aid of these principles, that we have at least done all that is possible in the search for the conditions of most economical operation.

An Instructive Example of Civil Engineering Organization.

For the information of the European engineering journals which have been expressing considerable amusing banter over the example of American methods afforded by the inchoate condition at Panama, for considerably more than a year, there is printed elsewhere in this issue an instructive statement of what has been accomplished in less than a year by the Board of Water Supply of New York City, a record of which is far more typical of our engineering procedure than that at the Isthmus. The undertaking in charge of this Board will probably be almost as costly as some of the estimates for a high-level canal at Panama and presents a greater variety of important technical problems, but nevertheless it is much farther advanced to-day than the isthmian waterway. The explanation for this admirable progress is perfectly simple; the three members of the Board recognized from the outset that they were neither engineers nor sufficiently educated along technical lines to pass judgment on engineering problems, and they have accordingly devoted their time to helping forward their engineering department and transacting business matters in which their experience can be profitably employed. The result of this policy, which shows the sound common sense of the Board, is the present advanced stage of this great municipal enterprise.

To the lay mind, to the man who is looking only to see the dirt fly, it may seem as if very little had been done during the year. To those who can understand it is little less than astonishing that such a volume of work should have been so well done under the prevailing conditions. The importance of this preliminary work and the wisdom of doing it thoroughly will be fully recognized when one considers that construction could not be safely undertaken on a large scale in any part of the system until the general problem of location and design had been sufficiently worked out to determine the critical points, for all are closely inter-related. Comparisons with other large engineering works of recent date cannot be made to "go on all fours," but a few statements, incomplete though they may be, of the time consumed on preliminaries may serve to indicate that time has not been wasted by the Board of Water Supply and its engineers.

On the Metropolitan water works for Boston, starting with an excellent preliminary study by the State Board of Health, eight months were advantageously consumed in organizing, surveying and designing before the first contract was let, for the Wachusett aqueduct. Much longer time was consumed in preparing economically for construction on the Weston aqueduct of the same system. These aqueducts are respectively twelve and thirteen miles long. For the preliminary work of the new Croton aqueduct more than eighteen months were required. Owing to peculiar difficulties, not wholly of an engineering nature, five years and ten months elapsed between the signing of the act creating the present Board of Rapid Transit Railroad Commissioners of the city of New York and the formal beginning of construction. For the much smaller Boston subway eight and a half months were used in preliminaries. For the Philadelphia filtration system one and a half years were expended upon the final preparations. Without disparagement to any of the good work done on the projects mentioned it can be unhesitatingly stated that a most creditable showing has been made on this latest and greatest undertaking among municipal enterprises, estimated to cost approximately $160,000,000. In a city of some of whose public works departments have been notoriously permeated with disgraceful politics an organization far larger than any other has been created free from political taint and the work pushed vigorously. Although there may be breakers ahead, surely the city is to be congratulated that this most important water works project has been committed to such able engineers working under a board composed of upright business men. It would seem possible for other communities to do as well, but the key to the situation is the chief engineer, who must be wisely selected on merit and given the assistance of consulting specialists and a good staff of assistants experienced in their respective duties.

Expediting Machinery Deliveries.

In the purchase of modern industrial machinery the date of delivery by the manufacturer is often of greater importance than the first cost of the apparatus. The arrival of the equipment a week or two in advance of the promise of a competitor may easily result in an increase of earnings which will more than pay the difference between bids. A case in point is that of an electric railway which buys twenty new cars costing $50 each more than the lowest bidder offered, on the strength of two weeks' better delivery on the successful tender. If the shipment is made on time and no hitch occurs in transportation and installation, the $1,000 excess cost will be offset in two weeks by $6,820 in additional gross earnings upon the system, assuming that each car makes 12 round trips per day, with gross receipts of only $2 per car per round trip. This point is often passed by in the purchase of engineering equipment, and there is no possible doubt that in many instances, a great mistake has been made by adhering too closely to the lowest estimate in awarding the contract.

Under conditions of general prosperity as intense as those of the present year, it often occurs that the promised delivery fails, and the result is naturally no small annoyance to the purchaser, as well as to the progressive manufacturer. It is always desirable to bear this possibility in mind, and, if feasible, to plan for the delays which may sometimes be unavoidable on the part of the manufacturer. There is a wide difference of opinion at the present time concerning the wisdom of inserting heavy penalty clauses in machinery contracts. In any case, co-operation rather than friction between the purchaser and the manufacturer is essential to the successful execution of short time orders.

The purchaser can do much to help matters by placing his order for standard rather than special equipment in cases where the former will meet the requirements reasonably well. It is trite to point out that the creation of new designs, drawings, patterns, templates and jigs requires considerable time even in a highly organized factory, but the vast quantity of special machinery called for by purchasers of electrical apparatus in particular certainly indicates that there is a tendency in these days toward special designs, in spite of the broad range of standard machinery available for usual purposes. Without the creation of special equipment progress would soon come to a standstill, but there is no doubt that a more careful study of present and prospective operating conditions in many cases would demonstrate the fitness of established types of apparatus for the work in hand.

Time can frequently be saved by ordering equipment after the main points at issue have been settled, instead of waiting for complete and detailed factory proposals. Again, it is a good plan to ask for outside figures from the manufacturers at an early stage of the project, before too much time has been expended in detail designing of plants. Of course, the essential points must be determined and at least a preliminary order placed before construction work can be begun upon the plant or production commenced upon its equipment, but there is very little to be gained by holding back a large order until unimportant particulars can be formally supplied. The practice of different companies in starting factory work before the formal contract is signed by the purchaser is liable to vary considerably, but this is exactly the place where co-operation is productive of good. Certainly it is seldom necessary to wait until minute detailed drawings are completed before preliminary quotations are requested by the purchaser. As a rule the district offices of the manufacturing companies are well supplied with the essential features of standard equipments, and valuable suggestions often come from this source when the general proposition is made known. In times of prosperity it is most important that the purchaser look as far into the future as possible in regard to new equipment, for it is often impossible for a factory running day and night to ship an order inside of several months.

To consider in detail what the manufacturer can do to expedite shipments would require one to pass over a field too large for these paragraphs to cover. The production department of a great engineering works exists for almost the sole purpose of intensifying the speedy and economical manufacture of the company's product. The organization of the labor performed and the facilities for receiving new material, the stock system, equipment maintenance and arrangement, the elimination of "red tape" in the offices as far as possible, the facilities for handling the stock within the works, closeness of relations between the producing and the sales departments and the exterior transportation arrangements, all bear vitally upon the possible delivery. Much can be learned by analyzing the record of past production and deliveries.

The common practice of sending a personal representative of the purchaser to the factory from time to time to follow up production has been advantageous in many cases where the organization of the factory has not been adequate to insure continuous progress of the work, or where the manufacturer has become careless as to the fulfilment of delivery promises; but after all, little is to be gained by too great insistence upon individual rush work in manufacturing plants which are loaded to their full capacity and which are doing their best to meet shipment requirements. Probably the best result of visits to the factory is the personal acquaintance with actual production conditions which the representative of the purchaser gains by contact with the factory staff and business departments. This ought to pave the way toward that co-operation mentioned above, which is indispensible to the harmonious and effective fulfilment of contracts of this or any other character.

Notes and Comments.

The Stone in the Spoil Banks of the Chicago Drainage Canal is to be crushed and placed on the market, according to a contract that has been made between Mr. John M. Ewen, of Chicago, and the trustees of the Sanitary District. Mr. Ewen agrees to purchase about 22,000,000 cu. yd. of stone in these spoil banks at 10½ cents per cubic yard. He will also pay the district 50 per cent. of the net profits when the latter are 35 cents a cubic yard or less, and 66⅔ per cent. when they reach 70 cents or more per cubic yard. When the net profits are between 35 and 70 cents the district will receive a share in accordance with a sliding scale ranging from 50 to 66⅔ per cent.

The Collapse of a Building in South Framingham, Mass., on July 23, resulting in sixteen deaths and numerous injuries, will probably be heralded as an instance of the dangerous nature of hollow concrete blocks, which entered extensively into its construction.This conclusion hardly seems justified by such facts as can now be ascertained. The building was a three-story 150x70-ft. structure, and people who witnessed its failure reported that the roof and floors sank, the roof apparently falling first, although plasterers working on the ceiling below noticed just before the accident that the fresh plaster was cracking even after being surfaced over a second time. This observation lends considerable appearance of truth to the belief that the failure was due to settlement of some of the piers of the interior columns. There is a bed of quicksand about 12 ft. below the surface, which has been encountered in the construction of sewers. It has a jelly-like consistency when confined and transmits for half a mile, it is stated by a local engineer, the jar of a passing railway train. It is probable that the collapse was due to this cause and not to the use of concrete blocks, particularly as the plans of the building, which was to contain the post-office, were examined by the architects of the Post-Office Department and approved, and the construction inspected from time to time.

The Cape to Cairo Railway in Africa was not, as has been generally reported, the direct beneficiary of the £1,200,000 left by the will of the late Mr. Alfred Beit for railway enterprises in Africa. When the real conditions of Mr. Beit's will were made known it became evident that while the Cape to Cairo route was borne in mind, the main object of the bequest is to assist railway construction primarily in Northern and Southern Rhodesia, in the East and West Portuguese Africas, and in German East Africa. As the extension northward of railways in Rhodesia lies in the direction of the Cape to Cairo Railway, the money available for such extensions will naturally help the transcontinental route. Furthermore, if that route after leaving Rhodesian territory is to pass through German East Africa to the east of Lake Tanganyika instead of through the Congo territory to the west of it, the funds should materially benefit that enterprise. Neither East nor West Portuguese Africa, which are both specified as localities where some of the money is to be applied, lie anywhere near any feasible Cape to Cairo route. The Engineer, in commenting on the provisions of the bequest, is of the opinion that although the Cape to Cairo Railway is mentioned incidentally in the legacy, Mr. Beit's main object was to encourage practical railway extensions in those parts of Africa with which his interests while living were more closely associated, and that the transcontinental route is still a dream.

Rock Excavation was the subject of a suit recently settled by the Supreme Court of Pennsylvania, 64 Atl. Rep. 742. Coatesville Borough advertised for bids for sewer work, specifying that rock excavation would be paid for at $3 per cubic yard. None of the tenders were accepted and the work was advertised the second time, the borough to furnish materials and the contractor to do the work. One of the bids received this time was accepted; it contained no reference to rock excavation, although considerable had to be done. The contractors claimed that reference to such work was omitted from their bid because the price for it had been fixed by the borough in its original specifications. When their contract was submitted to them for their signature they objected that nothing was said about rock, but claimed that the borough engineer assured them that it would be paid for at the established rate. Their counsel therefore claimed "where a written contract has been signed, and, at the time of its signing, it was mutually agreed that a certain thing should not be included or considered as included in the contract, testimony is properly admissible to determine the question as to what the contract was intended to include." The court ruled that if the negotiations had been between the parties to the contract the testimony on this point would have been sufficient to carry the case to the jury. But the contractors dealt only with the borough engineer, who was not a party but merely an agent with limited authority. Unfortunately for the contractors, the court said, there was nothing to show that the borough council either contemplated any rock excavation or authorized the engineer to contract for it, and consequently the claim made for it was rejected by the court. This case is another proof of the necessity of having a clear written agreement covering all features of such work.

The Contact Bed as a method of sewage treatment had a great vogue in Great Britain for some years, but of late it seems to have fallen into less favor, mainly on account of the difficulty of keeping it in an operative condition. Not only do the spaces in the filling material become clogged with suspended matter deposited from the sewage, but the material of the bed breaks down and causes the same result, owing to the use of soft clinker and other substances. Just why such poor filling is employed so extensively it is difficult to understand, for it reduces the effective life of a bed considerably. Mr. Dibdin, who introduced contact beds in many English cities, has lately devised a new method of constructing them in a cellular form of durable slate, as explained elsewhere in this issue. This construction does not do away with the accumulation of deposits within the bed, but it had been found practicable to clean out some small beds of this type by flushing the cells with a jet from a hose. These results are of much interest, and are confirmed by the experimental work of Dr. Travis, recently described in a paper before the Institution of Civil Engineers. He built some contact beds of slate at Hampton, in which the slates were arranged vertically instead of horizontally, as in Mr. Dibdin's design, in order that the accumulations of suspended matter on the walls of the vertical cells would fall off after reaching any considerable thickness, and thus be carried away by the liquid during the periodical draining of the bed. In this case, special precautions were taken to intercept sediment and detritus before the sewage reached the contact bed. These investigations show that the future of this system of treatment may be more promising than it has been considered by numerous observers, although it may be questioned whether cellular beds are practicable on a large scale. Their maintenance expenses remain to be ascertained, and the meager information concerning them at present indicates that their field of usefulness will be confined to works for treating the sewage of relatively small communities.

THE DISPOSAL OF THE SEWAGE OF PATERSON, N. J.—I.

The Treatment of a Municipal Sewage Containing Large Amounts of Mill Matter.

By Allen Hazen.

The Passaic River is polluted to an offensive extent, and the comfort and welfare of those living near it require that it should be cleaned. The object of this investigation was to find out whether the city of Paterson by itself had better build sewage purification works, and purify the sewage before discharging it into the Passaic River, or join with other municipalities in the construction of a trunk sewer to carry the sewage to a point of tidal discharge in New York Bay, or elsewhere.

The local purification of the sewage is more difficult and expensive because of the large amount of waste from the dye-houses and other manufacturing establishments; and the question of the collection and purification of this waste when mixed with the city sewage has been investigated at length. The pressure of this waste it is estimated will add 50 per cent to the cost of treating the sewage.

Extended investigation has also been made of the best means of purifying the sewage of Paterson. Visits to representative sewage purification plants in Great Britain and elsewhere have been made; experimental investigations recently carried out in this country have been considered; and an outline plan of a plant suitable for the treatment of the Paterson sewage has been made. A site suitable for this plant has been found and surveyed.

The trunk sewer project has been investigated at length, principally along the lines recommended by the Passaic Valley District Sewerage Commission, but modifications have been considered.

The conclusions reached are briefly that from a physical standpoint there is no good reason why the sewage of the Passaic Valley should not be discharged into tide water, either in New York Bay, as proposed, or in Newark Bay near the end of Kill von Kull. There may be legal or political reasons why such discharge cannot be allowed. If these matters can be adjusted, so that a free tidal discharge of crude sewage can be obtained, then clearly it is best for Paterson to join with the other municipalities in the construction of a trunk sewer. It is cheaper to carry the sewage to tide water than to purify it.

If, on the other hand, legal or political objections to the discharge of crude sewage into New York Bay or Newark Bay should prevail, then it would be necessary to purify the sewage from Newark and the other cities using the trunk sewer before discharging it. If the sewage from the trunk sewer is purified, then clearly Paterson cannot afford to join with the other municipalities in the trunk sewer project. It will cost as much, or nearly as much, to purify the sewage below Newark as it will to purify it near Paterson, and the cost of building the trunk sewer to carry the sewage for so long a distance remains as an unbalanced or only partly balanced item, the cost of which Paterson can save by treating her own sewage.

Either the trunk sewer or local purification would completely serve the desired end of preventing the pollution of the Passaic River by Paterson, although in either case it is essential that the dye-houses and other manufacturing establishments be required to connect with the sewers. The Passaic River cannot be adequately purified without doing this. The regulation of these connections is a new subject in America, and it will very likely require new laws to adjust this matter so as to do justice to all. The cost of the necessary works will be very great, whichever plan is adopted, and special legislative assistance will be required to allow the financial arrangements to be made.

Some of the more detailed results of the investigation are as follows:

Population to Be Provided For.—The population of Paterson, by the census of 1905, is 111,529; in addition, about 22,000 people live in territory immediately adjoining Paterson, and naturally draining through it, and so located that it will be very difficult for them to be provided with sewers without carrying the sewage through Paterson. Some of this population outside of the city is of such a character that sewers will be required at no distant date. The population is increasing at the rate of 3 per cent. per annum, or 34.4 per cent. per decade. About 89 per cent. of the population of the city is now connected with the sewers and this proportion is gradually increasing.

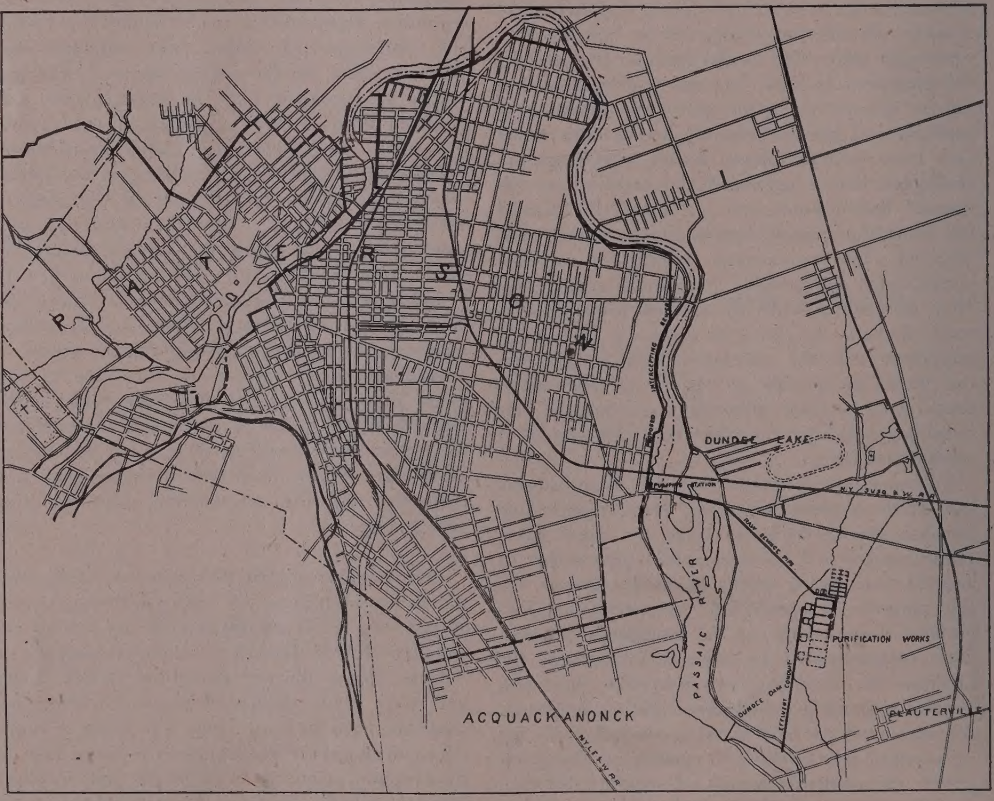
Manufacturing Wastes.—In the dye-houses of Paterson are handled every year about 7,500,000 lb. of raw silk, and from 500 to 1,000 gal. of water are used for each pound of raw silk. The total amount of water used in this way seems to be fully 200 gal. per capita daily. Practically none of this water is furnished from the public supply. Some of it is obtained from artesian wells and wells in the gravel; some of it is obtained from the Passaic River above the city, and some of it from tributaries. A large part of it is filtered before use.

A small part in volume of the manufacturing wastes is concentrated, containing soap and other organic substances. The waste coloring matters are the most conspicuous feature of these wastes. The great bulk of the volume of these wastes consists of extremely dilute wash waters, containing only mineral matters, or organic matters in such a high state of dilution that they do not tend to pollute the river. Extended data have been collected in the dye-houses, and it is estimated that not more than 5 per cent. of the volume of the liquors are of a polluting character. It would be impossible to separate them exactly upon scientific lines, and therefore for the purpose of estimate it is assumed that 10 per cent. of the volume of the liquors will require to be removed and purified in case the sewage is purified.

The gas works discharge liquids containing oil and tarry liquors, which have extremely offensive odors. The discharge is not continuous, but the contents of the tanks are let out from time to time. This material can and should be treated before it leaves the gas works.

The other manufacturing wastes in Paterson are not unusual or greater in amount than would be found in most cities.

The evidence collected leads to an estimate that the manufacturing wastes would increase the volume of sewage to be removed and treated by 25 per cent. and would increase the difficulty and expense of treating it by 50 per cent.; and these figures are used in making the various computations.



Location of Proposed Intercepting Sewers and Purification Works.

Storm Water.—Paterson has the combined system of sewerage. The sewers at the present time serve an area of 2,752 acres, or 56 per cent. of the total area of the city which will ultimately require sewers. Paterson and the greater part of Newark are sewered on the combined system. Substantially all the rest of the Passaic Valley is sewered on the separate system.

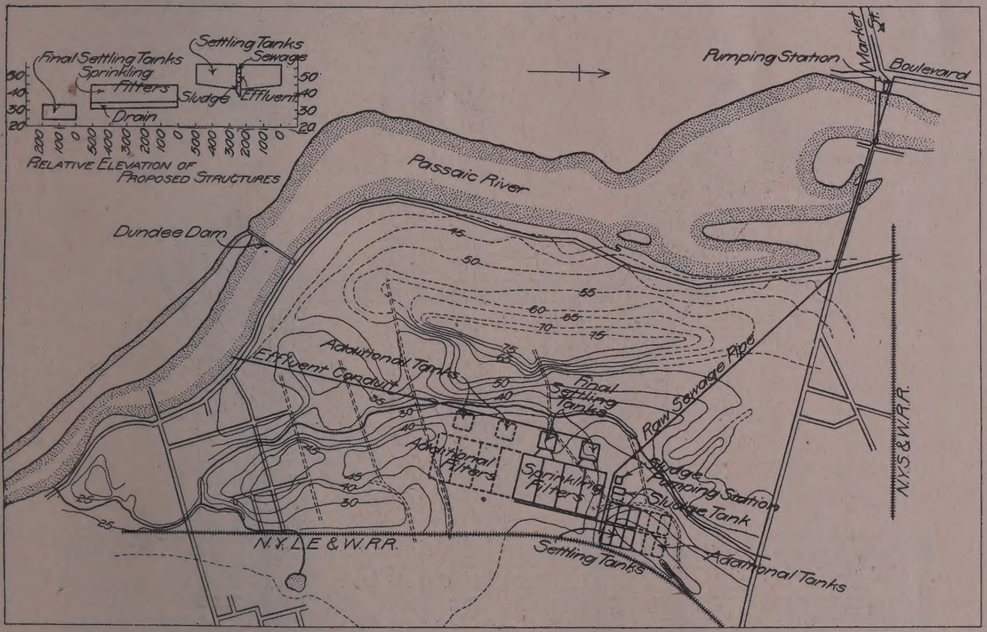
The storm overflows in winter do not cause much trouble, but in summer trouble is likely to take place as the result of local thunderstorms at times when there is no adequate dilution in the river, and they thus add largely to the pollution in the river. It is believed that a separate system will ultimately be adopted, and it is recommended that the sewer system be gradually reconstructed, and that all future work be done with reference to the adoption of this system.

The sewers of Paterson at the present time are not regularly cleaned or inspected. Some of them cannot be inspected because the manhole covers have been built over in paving and improving the streets, leaving the sewers quite in-accessible. The slopes are irregular. Where a flat slope follows a steep one, deposits often form, and such deposits also form where back water from the river checks the flow. Many of the sewers are filled at the present time to a very considerable extent with deposits of this kind.

In order to secure a reasonable and economical development it is necessary first to have a full and correct survey of the sewers now in use, and then to have a complete plan made for the development of the system, to serve as a guide to future construction.

The cost of installing the separate system, doing the work gradually, and taking advantage of times when repaving is being done, so as not to require the cutting of existing pavements, in the course of twenty-five years, during which time it is estimated that the system can be substantially and sufficiently changed, is estimated at $550,000. An annual appropriation for this period equal to 10 cents per capita will suffice to do this work, and this is taken as the cost of installing the separate system.

The separate system is equally necessary for the trunk sewer or for local purification works. The storm water is precisely the same in either case. It is the effect of this overflow upon the river which controls. The reason for removing it, and the method of doing it, are exactly the same in either case.



Arrangement of Proposed Purification Works.

Amount of Dilution Furnished by the Passaic River.—At the present time a part of the water which would naturally flow in the Passaic River is diverted for water supply purposes. The minimum flow is now about 45 per cent. less than the natural minimum flow. The ordinary flow is reduced by a much smaller percentage. This reduction in the natural flow is a substantial element in reducing the dilution of the sewage and increasing the nuisance resulting from it. It is not the sole nor the principal cause of the nuisance, however; for if the full natural flow of the river were now restored, it would not suffice to remove the present objectionable conditions. If the project of the Flood Commission should be carried out, with auxiliary storage, it would be possible to increase the minimum flow of the river probably to 50 per cent. more than its natural minimum flow, or to two or three times its present minimum flow. Such an increase in the flow of the river would not suffice even at the present time to purify the river and make it unobjectionable, much less would it suffice to meet future conditions. It would help substantially, however; and with this project carried out, the separation of storm water might be made more slowly, or even postponed for a time. Minor manufacturing pollutions would be of less importance, and in general the river could be kept in good condition with less effort and expense than would be necessary to secure corresponding results without this storage.

Works for Purifying Paterson's Sewage.—A large number of methods for purifying sewage have been proposed in the past, and there is great variety in the works in actual use in different cities. At first thought it would seem to be a difficult matter to weigh the merits of the different systems of purification and to decide which to use. But in the last years there has been a very great advance in the art of sewer purification, and this advance has simplified the problem. This has come about through carefully conducted experiments in Massachusetts, in England, in Germany, at Columbus, Ohio, and other places, and by wide experience in purifying sewage on a large scale; and the result of this experience has been to show the impracticability of a great many methods formerly proposed and advocated, and to simplify the remaining methods, and on the whole to unify them; and at the present time there is far less divergence between methods of sewage treatment than was the case five or ten years ago. The problem is now narrowed down until only a few different methods need be considered, and even among them several are so closely allied that they really form but different parts of one general method.

Methods of Purification Considered.—In the first place intermittent filtration or irrigation, or anything like a land treatment of the Paterson sewage is impossible. The necessary land for such treatment does not exist within practicable limits of distance. These processes might be considered in another location, for they are most useful where conditions permit; but for Paterson they are out of the question, and they will not therefore be further considered in this report.

The general method of treatment best adapted to the Paterson conditions is clearly indicated by European experience as found by Mr. Hewat, a member of the committee, and my partner, Mr. Whipple, who visited European plants to study them; and also by the report of Mr. H. W. Clark, chemist of the Massachusetts State Board of Health, who has had a wide experience in such matters, and whose opinion I obtained on this question.

The type of works thus indicated is that which, with variations, has been adopted in most of the newer and more important sewage purification works in England and in this country, including the plant now under construction at Columbus, Ohio, and the plan just adopted for Baltimore. A brief description of this method, and of the works required to carry it out for Paterson is as follows:

Description of Works.—An intercepting sewer is to be built following the river, collecting the sewage from each of the present outlets and carrying it to the foot of Market St. At this point a pumping station would be built to throw the sewage through a pipe line 1¼ miles long to the purification works. The sewage would then enter settling tanks holding half a day's flow. These tanks will be built to allow the deposits of sludge to be removed from them frequently and cheaply, and so that any tank can be cut out and cleaned while the others are in service. These tanks may be used as septic tanks, in which case the sludge will be removed only at long intervals; or they may be used as plain settling tanks, in which case the sludge will be removed frequently to avoid septic action; or chemical precipitation may be carried out in them, in which case apparatus for applying the chemicals to the sewage before it reaches the tanks must be added.

The construction and size of the tanks for the three different systems are substantially the same, and it makes but little difference for purposes of construction and estimate under which name they go.

The sludge removed from these tanks is to be taken to a second series of tanks, called sludge tanks, and it is proposed to make these tanks of considerable size. If the main tanks are used chiefly as settling tanks, as now seems advisable, the sludge tanks are to be of such size that sludge can be held in them on an average for a month, and with this done, it is expected that the sludge will undergo the septic process in them.

The septic process has the advantage over plain settling that it reduces the volume of sludge and makes it easier to handle and less offensive. It has the disadvantage, with reference to the effluent, that it greatly increases the odor from it, and especially the odor from the filters to which the effluent is applied. It would seem that using the tanks as settling tanks only, thereby avoiding the strong odor of the septic effluent, and putting the sludge from them through the septic process afterward in separate sludge tanks, would combine substantially the advantages of the two systems.

This idea is represented to some extent in a number of recent English plants, although it has not been carried far enough yet to show just what practical results can be obtained in reducing the volume of sludge by septic action when separated from the sewage.

During the winter the septic action in the sludge tanks will not be strong, while the application of sludge to land frozen and covered with snow may prove unsatisfactory. Consequently in cold weather it may be found advisable to use the settling tanks for septic sedimentation. The larger volume of sewage during the winter and the lower temperature would tend to prevent odors in the effluent.

Filters.—The effluent from the settling tanks, freed from some of the floating grease and the greater part of the suspended matter, will be taken to sprinkling filters. These filters are to be constructed in the present swamp. They are to have concrete bottoms, with very open drainage systems. The filtering material is to be 10 ft.

deep, of trap rock, crushed to go through a screen of 2½-in. mesh, and be held on a screen with a clear mesh of about 1 in. and washed substantially free from dust and fine matter. The settled sewage is to be applied to the top of these filters by numerous nozzles arranged to spray it over the whole area of the filters. Filters of this type are extensively and successfully used in England at the present time, and are now under construction at Columbus, Ohio.

These filters bring the sewage in contact with air and allow rapid oxidation of the organic matters; no straining is desired. All the suspended matter in the applied tank effluent goes through the filter, and in addition some of the dissolved matter is precipitated in the course of oxidation. It is essential to continuous satisfactory operation that there should be no permanent accumulation of insoluble matter in the filters, for such accumulation would finally choke the filtering material and prevent purification. The filtering material must therefore be so coarse that it will not act as a strainer, and the underdrains must be open and so arranged that they can be flushed, and all suspended matter must be constantly washed out, leaving no accumulation behind.

Final Settling.—The effluent from these filters is a turbid, unsightly liquid, but with much of the nitrogen converted into nitrates and the putrescible organic matters destroyed. The liquid is taken to final settling tanks holding two or three hours' flow, in which the bulk of the suspended matters is deposited. The resulting effluent is fairly clear and is free from the putrescible organic matters which so pollute rivers as to make them offensive.

Other Arrangements.—Arrangements must be provided for flushing and cleaning all parts of the plant, and for collecting the dirty waters resulting therefrom, and for taking them back to settling tanks, so as to collect ultimately all of the suspended matters in the sludge receptacles.

A certain amount of clogging of the filters will be inevitable, and after periods of ten or fifteen years the material in the beds will have to be removed and washed.

The sludge can apparently be best disposed of by putting it on and digging it into land. This will clearly be the case if the separated sludge goes through the septic action in the sludge tanks. Going through the septic process has the effect of largely deodorizing the sludge, reducing it in volume, and altering it to such a condition that it can be applied to land without making a local nuisance, this being one of the chief objects of the septic process.

It does not seem likely that the dye-stuffs in the sewage will be present in such quantity as to seriously discolor the effluent. The processes of purification above described have only a limited power in removing these dye-stuffs. If they should prove objectionable it would be necessary to apply chemical precipitation. This would make no considerable change in the construction of the plant, but would add materially to the cost of operation.

If a complete chemical precipitation process should be used the sludge to be disposed of would be greatly increased in volume, and it would be incapable of going through the septic action. Probably in this case it would be best to install sludge presses and press such sludge at considerable expense before applying it to land. It may be best to ultimately provide for disposal of sludge by carrying it to sea; but this seems unnecessary at the present time.

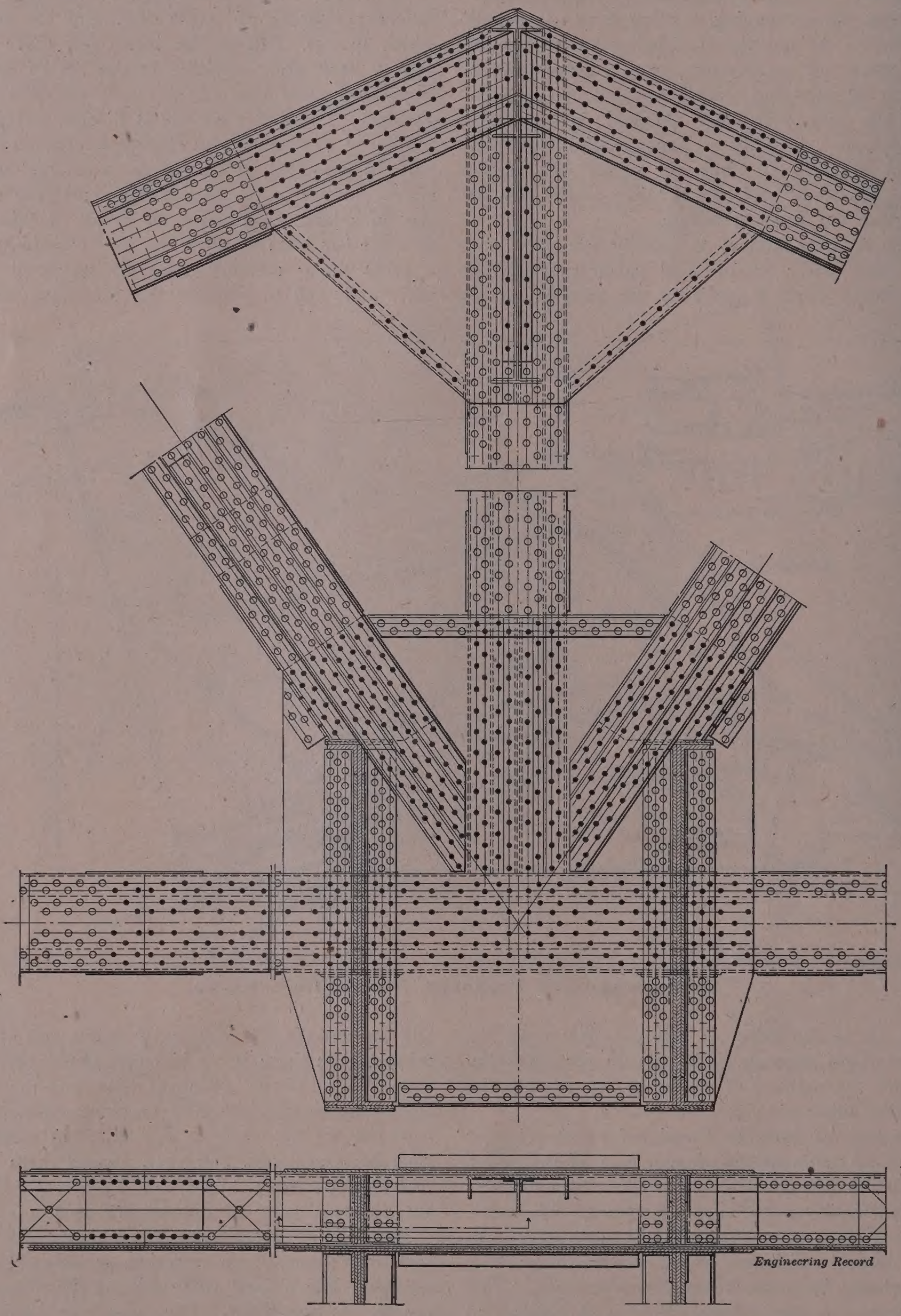
The effluent from the final settling tanks is to be discharged into the Passaic River through a conduit built for that purpose, entering the river a short distance below Dundee dam.

Land Required.—The construction of these works requires a very ample site. It is estimated that 500 acres should be secured. This land for the most part at the present time is a worthless swamp, but some higher and more valuable land is included.

It would not be wise to locate purification works in this neighborhood without controlling an ample site sufficient to give a good margin all around the works, and between them and the neighboring residences.

Amount of Sewage per Capita.—It is assumed that the dry weather flow of sewage is 100 gal. per capita; that the average flow is 125 gal., and that the maximum rate to be taken care of is 250 gal. per capita. The same figures are used for the trunk sewer project. Paterson probably has more manufacturing wastes per capita than the whole district, but probably, on the other hand, much less ground water enters her sewers. This is due in part to the compactness of the population, and in part to the extensive use of ground water by the dye-houses, which take a considerable part of the water which otherwise would find its way to the sewers.

In this connection it may be well to state that the Metropolitan sewers for Boston fifteen years ago were designed to have capacities ranging from 225 to 262 and averaging 238 gal. per capita, and experience has shown that these estimates were not too large. In making estimates for additional sewers in the same system at the present time, Mr. William M. Brown, chief engineer, uses basing capacities of from 251 to 300 gal. per capita daily.



Center Panel Point Connection, Elizabeth River Draw Bridge.

It is true that in Europe the quantities of sewage discharged are very much less than in this country; furthermore, there is a tendency to reduce the consumption of water here; and if a radical change takes place in this respect, the volume of sewage will be to a considerable extent reduced, and the life of the structures now built will be correspondingly increased. This is a possibility, but not a certainty, nor even a probability at the present time.

Estimated Cost of Purification Works.—The estimated cost of construction of works for local purification, sufficient for present requirements and arranged so that they can be easily extended as the population grows, is $2,400,000. Of this considerably more than half is represented by intercepting sewers, pumping station and other necessary structures not directly connected with the purification works.

(To be Continued.)

A Center Bearing 284 Ft. Double Track Draw Span

The Tidewater Railway crosses the southern branch of the Elizabeth River at Norfolk, Va., on a double-track four-span bridge, 689 ft. long, which consists of three fixed spans and one draw span, 284 ft. long center to center of end piers. The superstructure has heavy riveted Pratt trusses calculated for Coopers E-60 loading. The draw span has a dead load of 6,000 lb. per lineal foot, inclusive of an allowance of 900 lb. per lineal foot for track. This results in a very heavy structure weighing in all about 1,000 tons which, when the bridge is swung open to allow for the passage of vessels, is entirely carried by the center pivot; when the bridge is in service for railroad traffic it is supported at the end piers and at two fixed points on the pivot pier, thus transforming it into two separate 142-ft. spans. When in motion although the dead load is carried by the pivot, stability is insured by eight bearing wheels traveling on a track of 14 ft. radius concentric with the rack by which the bridge is swung.

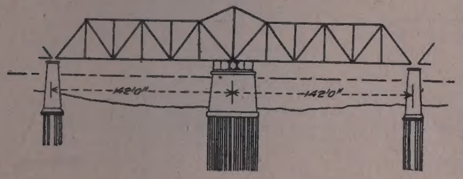
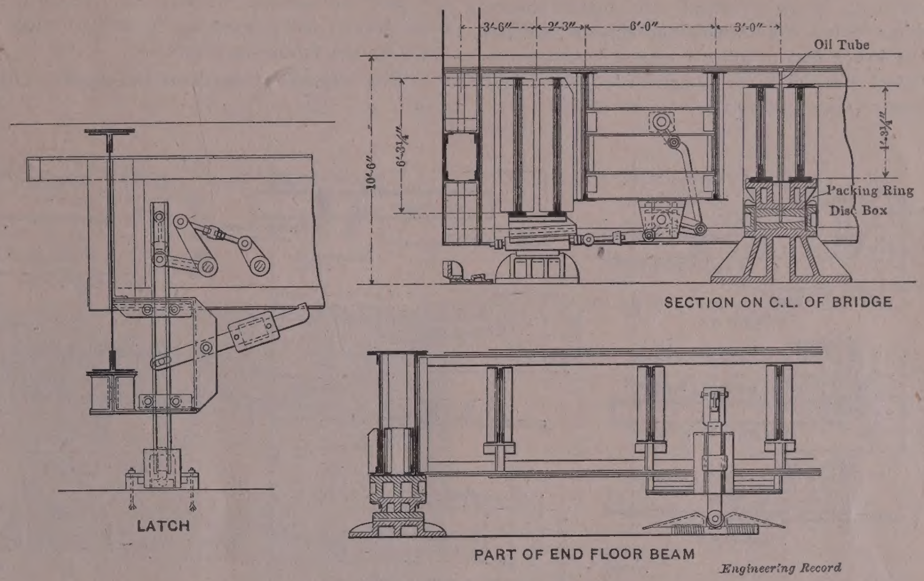
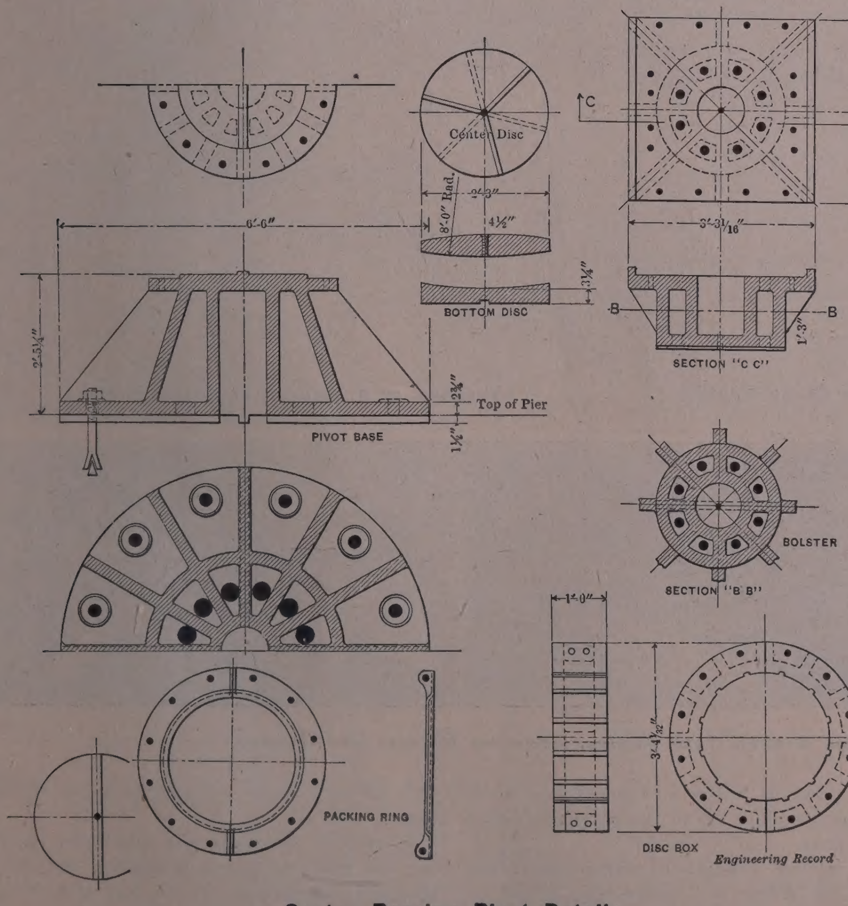


Diagram of Draw Span.



Wedge Pivot and Latch Details.



Center Bearing Pivot Details.

The trusses of the draw span have no pin connections and where the inclined end posts meet on the pivot pier they are connected with gusset plates 1⅛ in. thick and 10 ft. long to the continuous lower chords and to the vertical posts. These plates also serve as connections for the ends of a pair of massive transverse bearing girders 8 ft. deep and 7 ft. apart on centers, by which the weight of the span is transmitted to the pivot. The tops of the vertical posts are connected to inclined struts in the planes of the trusses by similar pairs of ⅞-in. gusset plates about 13 ft. long, which have their edges stiffened with flange angles and provide very rigid connections to the members connecting the hips of the trusses. Transversely the tops of these vertical posts are connected by deep lattice girder portal struts. The bottom chord over the pivot pier is made with two 26x9/16-in. webs and four 6x4x⅝-in. flange angles and like the vertical and inclined posts is connected to the gusset plates with ⅞-in. field rivets, of which there are a total number of about 2,400 in both trusses for the two panel points, L 6.

The transverse bearing girders are web-connected at each end by three plate girders and at the center by four plate girders, all parallel to the axis of the bridge. Two of the end girders receive on their lower flanges the upper bearings of the wedges through which live load is transmitted to the pivot pier. The third, together with one of the center girders, provides support for the mechanism by which the center wedges are operated. The two inside center, or yoke girders are seated directly on a cast-steel bolster, which forms the top of the pivot and carries the full weight of the bridge when the latter is open. This design provides a very simple and compact arrangement of girders and is comprised in a total height of 10½ ft. from the top of pier masonry to the base of rail.

The pivot is of very simple construction and is composed, as indicated in the assembled sections, of a cast-steel pedestal carrying three loose circular discs enclosed in a cylindrical case and supporting the bolster previously mentioned under the yoke girders. The pedestal is about 2½ ft. high and has a circular base 6½ ft. in diameter. There are twelve radial vertical webs 2½ in. thick with vertical and inclined connecting webs which virtually form a small center cylinder and concentric cone supporting the cap plate. The latter has a bearing about 27 in. in diameter for a forged steel disc, plane on the lower surface and concaved to a radius of 8 ft. on the upper surface. There is a corresponding reversed upper disc and between the two there is a loose, hard phosphor bronze polished disc, 4½ in. thick at the center, with three radial oil grooves in the upper surface and three corresponding grooves in the lower surface staggered from those in the upper surface and connected with them by a center vertical hole. The upper and lower discs have 2-in. circular recesses at the center to engage projections from the bolster and from the pedestal. The discs receive a maximum pressure of 3,000 lb. per square inch and are enclosed in a cast-steel cylindrical box bolted to the top of the pedestal. The inner surface of the box is provided with vertical oil grooves and oil is supplied to the discs by a pipe passing through the center of the bolster. The disc box is made in two sections with a vertical diametrical joint and is held in position by a horizontal ring made from 2½-in. rolled-steel splice plate. This is made in two pieces with their diametrical joints at right angles to those of the disc box. Above the splice ring is placed another ring recessed to retain packing. It is also made in two sections like the splice ring and is bolted to the latter besides having vertical flanges bolted together.

The cast-steel wedges and their bearings for the center and end piers are of very simple construction and all of them are substantially like the detail shown. The wedge is engaged between side guides and is operated by a pair of eye bolts which pass through it from end to end and are provided with a screw adjustment to set the wedge so as to provide for variable heights. All of them are operated by simple levers which are the equivalent of crank shafts and are actuated by gears from shafts driven from the center pier by electric motors. The wedge driving shafts also drive parallel shafts which have levers to operate the rail lifts and latches. The latch is made up of two vertical steel plates riveted together with a counterweighted support and has at the lower end a roller engaged between two cast-steel beveled stops attached to very heavy springs to take up impact.

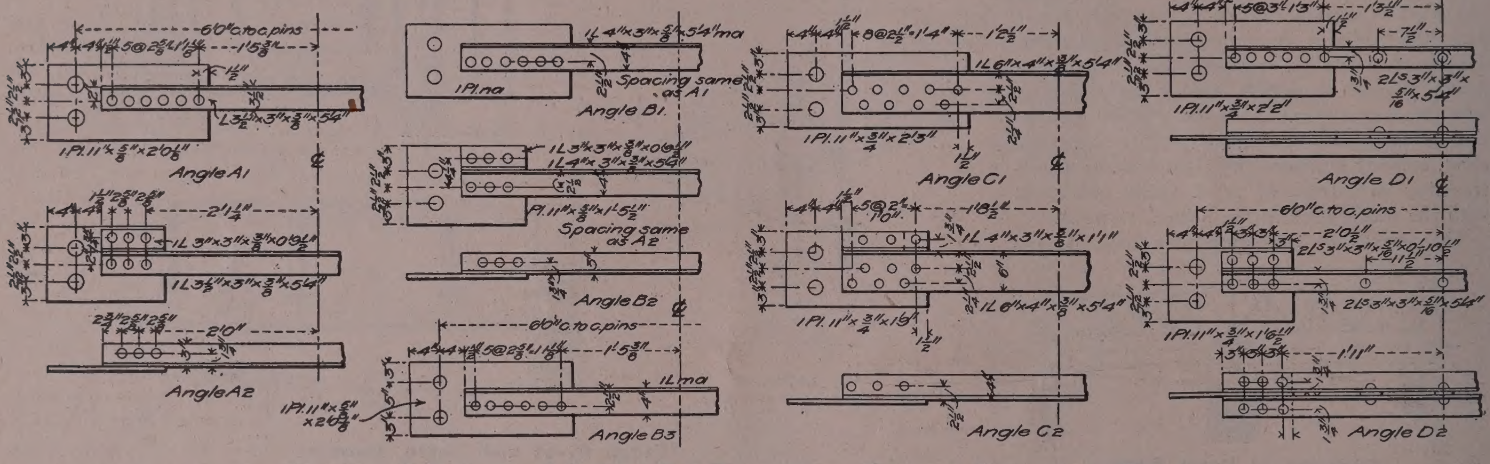
The operating mechanism is driven by General Electric motors with an aggregate capacity of 100 h.-p., 75 h.-p. for turning the draw span and 25 h.-p. for driving the wedges, and is thoroughly safe guarded by automatic signals, brakes and interlocking devices which provide for the proper sequence of operations. It is designed to be fully opened in one minute and closed in the same time. It was designed under the direction of the engineering department of the Tidewater Railway Co., Mr. H. Fernstrom, chief engineer, and Mr. F. F. Harrington, engineer of bridges. The details were prepared subject to their approval by the McClintic-Marshall Construction Co., contractors, under the immediate supervision of Mr. G. L. Taylor.

Tension Tests of Steel Angles With Various Types of End Connection.

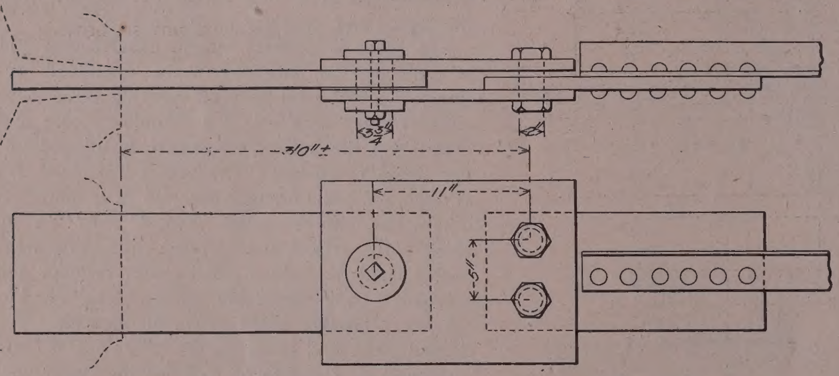
A paper read before the American Society for Testing Materials by Prof. Frank P. McKibben.

The tension tests which form the subject of this paper were made in the testing laboratory of the Massachusetts Institute of Technology upon 27 specimens of rolled steel angles such as are used for tension members in riveted structural work. They were made with a view of studying the following points:

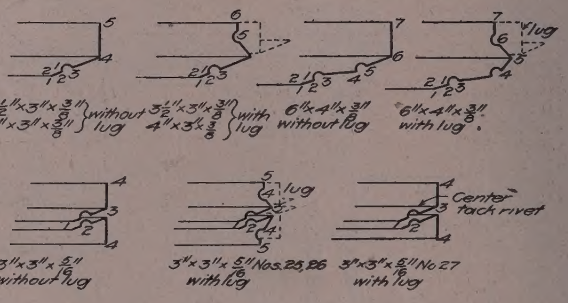
1. The ultimate strength of the angles in tension.



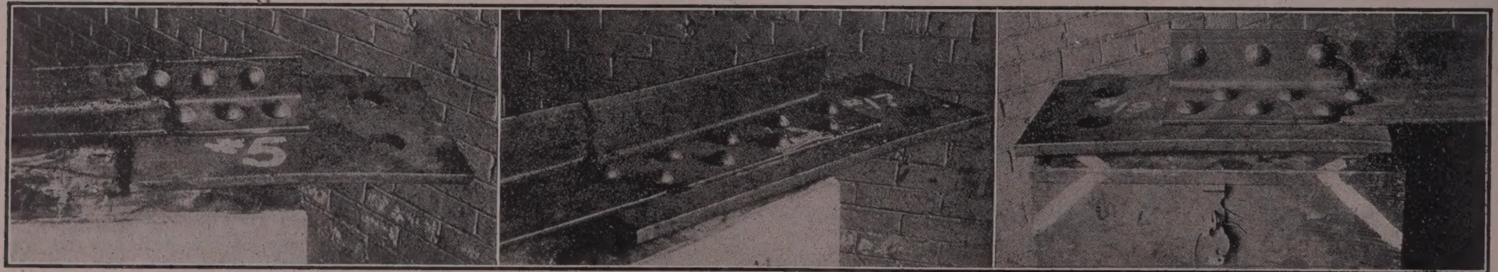
Details of Methods of Making End Connections Between Angles and Plates.



Arrangement of Rigging for Tension Tests of Steel Angles.


3½"x3"x⅜" 4"x3"x⅜" without lug
3½"x3"x⅜" 4"x3"x⅜" with lug
6"x4"x⅜" without lug
6"x4"x⅜" with lug
lug
3"x3"x5/16" without lug
3"x3"x5/16" Nos. 25, 26 with lug
3"x3"x5/16" No 27 with lug
Center tack rivet

Sketches of Fractures of Steel Angles.



A Close View of Three of the Broken Test Angles, Showing Manner of Rupture.

2. The value of a lug in transmitting stress from the outstanding leg of the main angle into the hitch plate.

3. The relative strength of angles where the gage-line for rivets and where the center of gravity line, respectively, pass through the center of the pull.

4. The relative strength of single angles and angles riveted together to form pairs.

There are three specimens of each of nine different types, making in all 27 specimens; the details of these types are shown in one of the accompanying illustrations, in which it should be noted that all angles had both ends alike; all angles were 5 ft. 4 in. long; ⅞-in. rivets were used; holes for rivets were punched 15/16 in. in diameter and pin holes 2 in. in diameter were drilled. Each of the main angles, 5 ft. 4 in. in length, is riveted at each end to a hitch plate.

Types A_1, B_1 and C_1 consist each of one angle, 3½ x 3 x ⅜ in., 4 x 3 x ⅜ in. and 6 x 4 x ⅜ in., respectively, riveted to the hitch plates by one leg only.

Types A_2, B_2 and C_2 consist each of one angle of the same size as A_1, B_1 and C_1, respectively, and have both legs connected to the hitch plates, the outstanding leg being connected by means of a lug angle.

Types D_1 and D_2 each is made up of two 3x3x5/16-in. angles, one on either side of the hitch plate. D_1 is not, and D_2 is, provided with lugs for each of the outstanding legs of the main angles.

In each of the types just mentioned the gage line for rivets in the main angle is run through the center line of pull. In the case of angles with unequal legs the long leg is placed in contact with the hitch plates.

Type B_3 consists of one 4x3x⅜-in. angle connected to the hitch plates by one leg only. It differs from type B_1 in that the line of pull coincides with a projection of the center of gravity line instead of with the gage line for rivets.

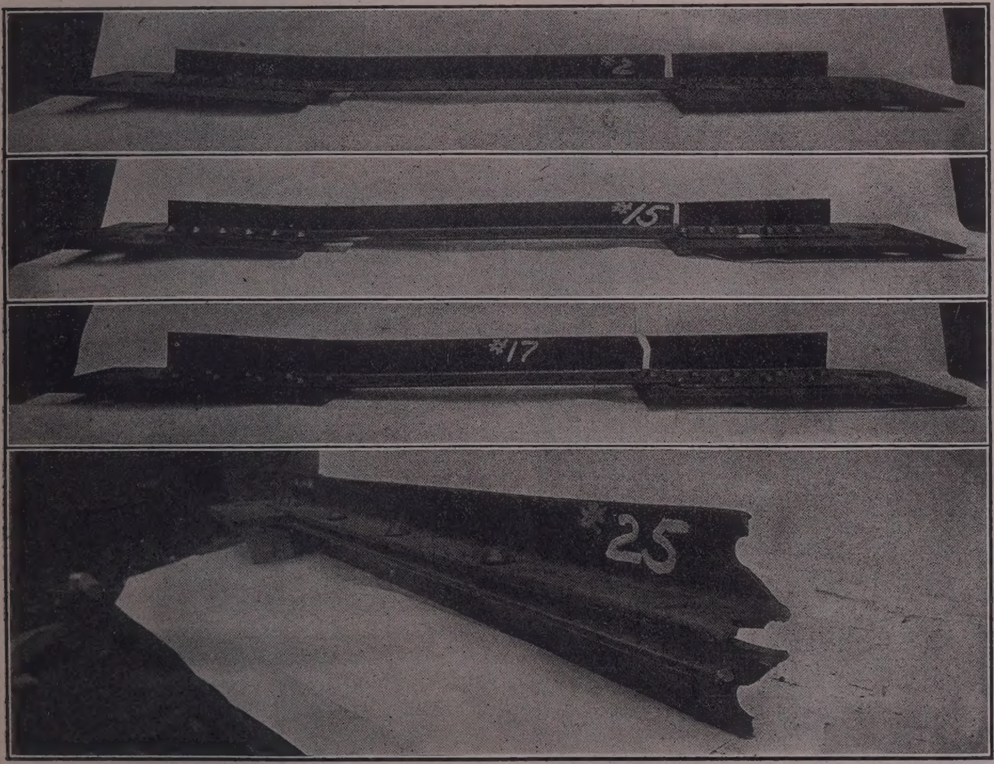
The end connections were designed to insure failure in the main angles, and the specimens were made as long as could be tested conveniently. The hitch plate at each end of each specimen was provided with two 2-in. holes, by means of which it was pinned between two holding plates fastened in turn by a single pin to a third plate gripped by the testing machine. A diagram of this holding device is shown in one of the illustrations.

All of the pieces of angles of a given size were cut from one long angle, and from each of these long pieces there were also made two small tensile test specimens. Table I gives the average results of the tensile tests on the small specimens which were approximately 18×1½×⅜ or 5/16 in. in size.

The outlines of the various fractures, all of which occurred in the main angles are shown diagrammatically in a third illustration. The small figures at the fractures in this illustration indicate the origin and progress of rupture. With the exception of one of the specimens, made of two 3x3x5/16-in. angles, failure took place at one of the inner rivets which connects the angle to the hitch plate, that is, the connecting rivet which lies nearest the center of the specimen. In the case of the exception noted, rupture occurred at the center of the specimen where there is a single rivet connecting the two angles together. In all cases just before failure the metal between the inner rivet and the outer edge of the leg connected by that rivet to the hitch plate, drew down considerably at both ends of the specimen. Failure then occurred at this point, continuing slowly across the horizontal leg and then up the vertical leg. With the one exception cited, failure occurred, in all specimens having lugs, on a zig-zag section passing through rivets in the horizontal and in the vertical legs. In order to secure the greatest strength from an angle in tension this zig-zag section should be equal to or greater than the net right section. In none of the specimens tested is this the case. Consequently the total ultimate strength of some of the specimens with lugs is less than that of similar specimens without the lugs. However, the strength per square inch of net area is greater where the lugs are provided, showing that with the proper spacing of rivets to utilize the maximum net area the lug is an advantage.

TABLE I.
TENSILE STRENGTH OF SMALL TEST SPECIMENS CUT FROM STEEL ANGLES.

Size of angle from which specimen was cut........	3½ x 3 x ⅜ in.	4 x 3 x ⅜ in.	6 x 4 x ⅜ in.	3 x 3 x 5/61 in.
Yield point, lbs. per sq. in..........................	33,160	31,600	32,600	34,800
Ultimate strength, lbs. per sq. in..................	59,300	54,000	51,600	61,000
Elongation, per cent. in 8 ins.......................	28.0	28.6	31.1	29.5
Reduction of area, per cent........................	48.9	54.6	56.5	52.6
Appearance of fracture............................	Silky	Silky	Silky	Silky



Typical Fractures of Tested Angles.

TABLE II.
SUMMARY OF TENSION-TESTS ON STEEL ANGLES.

No. of Specimens.		Nominal Size, in.	Area in Nominal.	Cross Section square inches. Actual gross.	Net.	Breaking Load Lb. Total.	Per sq. in. of net area.	Per cent. Strength of Material Developed.*	Remarks.
A_1	1	3½ x 3 x ⅜	2.30	2.29	1.95	89,500	45,900	77.4	Without lugs
“	2	“	“	2.32	1.98	96,100	48,500	81.8	
“	3	“	“	2.35	2.00	95,200	47,600	80.2	
“	Mean	“	“	2.32	1.98	93,600	47,400	79.8	
A_2	4	3½ x 3 x ⅜	“	2.28	1.78	84,600	47,500	80.1	
“	5	“	“	2.28	1.78	88,600	49,800	84.0	With lugs
“	6	“	“	2.27	1.77	91,200	51,500	86.8	
“	Mean	“	“	2.28	1.78	88,100	49,600	83.6	
B_1	7	4 x 3 x ⅜	2.49	2.44	2.10	85,000	40,500	75.0	
“	8	“	“	2.42	2.09	84,000	40,100	74.3	Without lugs
“	9	“	“	2.50	2.15	85,600	39,800	73.7	
“	Mean	“	“	2.45	2.11	84,900	40,100	74.3	
B_2	10	4 x 3 x ⅜	“	2.42	1.92	83,500	43,500	80.5	
“	11	“	“	2.43	1.92	85,100	44,300	82.0	With lugs
“	12	“	“	2.45	1.95	84,100	43,100	79.9	
“	Mean	“	“	2.43	1.93	84,200	43,600	80.8	
B_3	13	4 x 3 x ⅜	“	2.41	2.07	88,600	42,800	79.3	
“	14	“	“	2.42	2.09	90,400	43,200	80.0	{ Centre of gravity line through pull
“	15	“	“	2.41	2.07	91,000	44,000	81.4	
“	Mean	“	“	2.41	2.08	90,000	43,300	80.2	
C_1	16	6 x 4 x ⅜	3.61	3.53	3.11	131,000	42,100	81.6	
“	17	“	“	3.54	3.12	125,700	40,300	78.1	Without lugs
“	18	“	“	3.50	3.07	128,200	41,800	81.1	
“	Mean	“	“	3.52	3.10	128,300	41,400	80.3	
C_2	19	6 x 4 x ⅜	“	3.50	3.04	131,500	43,300	84.0	
“	20	“	“	3.50	3.03	130,200	42,900	83.2	With lugs
“	21	“	“	3.50	3.04	131,900	43,400	84.1	
“	Mean	“	“	3.50	3.04	131,200	43,200	83.7	
D_1	22	Two 3 x 3 x 5/16	3.56	3.44	2.88	134,100	46,600	76.4	
“	23	“	“	3.43	2.87	136,500	47,700	78.3	Without lugs
“	24	“	“	3.49	2.91	139,100	47,800	78.4	
“	Mean	“	“	3.45	2.89	136,600	47,400	77.7	
D_2	25	Two 3 x 3 x 5/16	“	3.43	2.69	137,900	51,200	84.0	
“	26	“	“	3.43	2.69	140,400	52,200	85.6	With lugs
“	27	“	“	3.42	2.86	138,800	48,500	79.6	
“	Mean	“	“	3.43	2.75	139,000	50,600	83.1	

*Figures of previous columns compared with specimen tensile test results of Table I.

Table II shows in detail the results of the tests. Table III shows the per cent. increase in the strength per square inch of net area due to the lugs.

The results of the tests show that the ultimate strength per square inch of net section for angles having gauge lines for rivets passing through the center of pull varies, for the single angles, from 39,800 to 51,500 lb., which is approximately from 74 to 87 per cent. of the strength of the tensile test specimens; and for angles riveted together in pairs, from 46,600 to 52,200 lb., which is approximately 77 to 86 per cent. of the strength of the material as developed by the tensile test specimens.

The efficiency of the lug is shown by the fact that for specimens provided with lugs there is an increase over specimens not so provided of from 4.7 to 8.7 per cent. in ultimate strength per square inch.

A study of the results of the 4x3x⅜-in. angles without lugs shows that there is a gain of 8 per cent. in the strength per square inch for specimens having the line of pull coinciding with the projection of the center of gravity line instead of the gage line for rivets. It further appears that for these angles the strength per square inch is practically the same for those specimens having the center of gravity connections without lugs as it is for those having the gage line connections with lugs.

TABLE III.
SHOWING VALUE OF LUGS.

		Ultimate strength per square inch of net section.	Increase in strength per square inch of net area.
A_1	Without lug	47,400	—
A_2	With lug	49,600	4.7
B_1	Without lug	40,100	—
B_2	With lug	43,600	8.7
C_1	Without lug	41,400	—
C_2	With lug	43,200	4.4
D_1	Without lug	47,400	—
D_2	With lug	50,600	6.8

Notwithstanding the fact that the net as well as the gross area of the two 3x3x5/16-in. angles is less than in any of the single 6x4x⅜-in. specimens, yet the ultimate load carried by the former is greater in every case.

This is no doubt largely due to the greater strength of the material in the double specimens on account of their smaller size and thickness.

In closing the writer wishes to express his obligations to Messrs. Arthur L. Davis and S. P. Waldron, of the American Bridge Co., for the specimens tested, and to Messrs. A. F. Holmes, instructor, and C. T. Bartlett and H. P. Orcutt, students in the Massachusetts Institute of Technology, who carefully did the work in the laboratory.

STRICT ENFORCEMENT OF THE SAFETY APPLIANCE LAW by the railroads of this country is evidenced in a recent order of the Pennsylvania lines that in the future no cars be operated or accepted from other lines which are not properly equipped with air brakes.

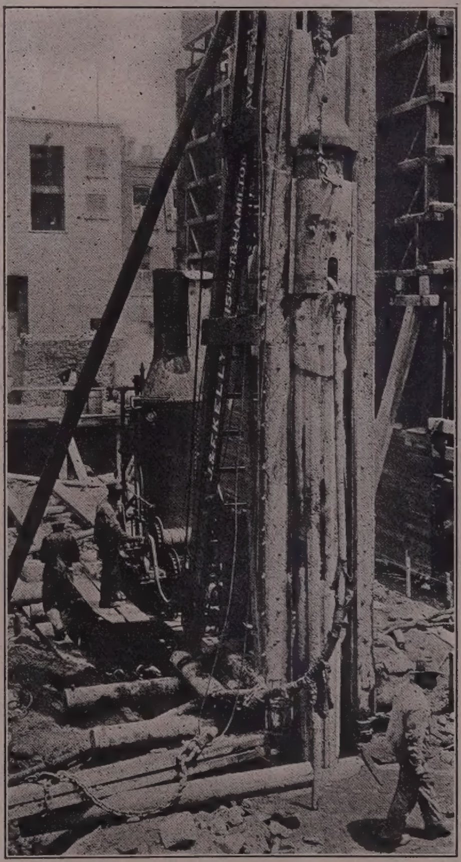
Corrugated Concrete Foundation Piles for a Seven-Story Building.

A 94½ x 99-ft. factory building at 536 West 27th St., New York City, has the columns and walls supported on clusters and rows of corrugated concrete piles, 225 in all, including those used for the engine and boiler foundations. The site, like many others in New York City, was located so there was a possibility of the ground water level being lowered by subsequent construction or excavation in the neighborhood. Wooden piles would therefore be in danger of decay, and any other form of substructure which would carry the foundation loads to the rock was so expensive that concrete piles were selected on account of the rapidity and facility with which they could be constructed and on account of their strength and durability. Under two walls of the building there are double and triple rows of staggered piles, about 5 ft. apart in the row. Most of the column piers sustain loads of 120 tons on 4 piles, 3 ft. 8 in. apart on centers, with their tops engaging concrete footings 7 ft. square. Similar reinforced concrete footing, 5½ ft. wide, engage the tops of the piles under the walls, thus making a continuous platform to receive the substructure.

Before the construction was commenced a thorough subterranean exploration of the site was made by the usual wash-pipe process which showed that the surface of the rock, from 30 to 40 ft. below the street, was very irregular and was covered with a 2-ft. stratum of gravel, above which there was a fill of loam. The piles were therefore made of from 20 to 30 ft. long and reinforced with 8 longitudinal steel bars arranged near the outer surface and tied together horizontally. They were manufactured at the site by the method followed in constructing the piles for the building of the Judge Publishing Co., which was described in The Engineering Record of Nov. 11, 1905. The piles tapered from 20 in. at the butt to 11 in. at the tip and were made with a concentric hole, tapered correspondingly from 6 to 3 in. Special care was taken in making these piles to turn the core for this hole at frequent intervals to prevent it adhering to the concrete until the latter was thoroughly set. For this purpose a man was continually on duty and night to twist the core several degrees every few hours with a long-handled pipe wrench. As the core was tapered this tended to cause it to move outwards in the mould, an effect which was not objectionable. The concrete was mixed by hand at the site in proportions which varied according to circumstances from 1:3:5 to 1:4:4, the richer mixture being used when it was desirable to drive the piles as soon as possible after being manufactured. Atlas Portland cement was used and the piles were driven when from 10 to 35 days old. Only one pile was broken in driving and it broke near the center of gravity while being raised to the leads, the accident being attributed to the lack of age of the concrete.

The piles were sunk by means of a hydraulic jet and an ordinary 3,000-lb. drop hammer. The hammer struck on a cap made to enclose the pile and prevent the concrete from being injured by the impact and was used in connection with the hydraulic jet to give settling blows to the piles. The cap consisted essentially of a steel sleeve with lugs riveted to it inside to receive a horizontal steel diaphragm plate under which a wooden block was inserted to bear on the top of the concrete. The space above the diaphragm was nearly filled with rubber and rope packing on which was seated a wooden hammer block that projected above the top of the sleeve and had free vertical movement. Its upper edge was protected by an iron ring and it served its purpose in transmitting the inertia of the hammer to the pile without injuring the latter. The piles were handled like ordinary wooden piles, and after being placed in the pile driver leads were connected to a hydraulic jet operated by a No. 10 Cameron pump. A 2½-in. hose was coupled to a vertical 2½-in. wrought-iron pipe placed inside the pile and provided at the bottom with a 1¼-in. nozzle. The pipe connection passed over the top of the pile through a slot in the cap which provided for vertical movement relative to the pile. The jet had a pressure of about 100 lb. per square inch and aided by light blows of the hammer drove the piles to refusal on the surface of the rock. Eight men drove a maximum of 14 piles and an average of six piles daily.

The reinforcement bars projected some distance above the tops of the piles and after the latter were driven they were flatened down and served to bond the piles thoroughly into the reinforced-concrete footing enclosing their upper ends. This footing was built in two courses; the lower one reached just up to the tops of the piles and on it were set the ⅞-in. round diagonal bars and the ¾-in. round longitudinal and transverse bars which form the reinforcement. These were carefully secured in position and the concrete was rammed around them in the form which also served as a sheeting for the pier excavation.



Pile in Leads.

Mr. John Williamson is the owner of the building, Mr. C. H. Caldwell the architect and Mr. John C. Wills, Inc., is the general contractor. The substructure was built by the Corrugated Concrete Pile Co., Mr. J. W. Mair, chief engineer. The contract was awarded March 7, 1906, and although considerably delayed by bad weather the work was finished July 10. It is believed that but for the delays some changes and extra work, the contract would have been completed May 15.

ONE OF THE LARGEST ROCK CRUSHERS yet built has a capacity for crushing 700 tons of rock per hour and weighs 100 tons. It is being installed at Little Falls, N. Y., to crush stone for railroad ballast and concrete work.

A Sand Trap for Irrigating Ditches.

By H. A. Crafts.

One of the prolific sources of cost in the maintenance of irrigating canals and ditches is the removal of the sand and silt held in suspension in the general water supply, and carried in during the running of full heads, especially during the prevalence of the annual flood tides. It is during such periods that not only the largest amount of water is used, but at those times there is also the largest percentage of vegetable and mineral matter to be found in the smaller streams from which the water supply is obtained. Of course conditions vary according to the character of the water shed, state of flood tide and constructive character of the ditches. Torrential streams almost invariably discharge during freshet periods large amounts of alluvial matter brought in, not only from numerous tributaries, but also from the parent banks, shoals, eddies and other sources, because, as is well known, nearly all such streams are perpetually changing their courses, thus cutting into new soil bodies and carrying the loosened matter downstream.

Heavy and protracted rains on a water shed, or the sudden melting of large snow bodies near the head waters, or cloud bursts are always productive of land wash, and streams in a short time become roily. I have seen streams in Colorado running so muddy after one of these disturbances that the irrigation superintendents considered it good policy to shut down their main head gates to await clearer water, although at the same time the crops under the ditches might be in great need of moisture. It simply became a question of whether a shut-down pending the flow of clearer water would be more costly than a shut-down for the clearing out of clogged ditches, and the managers usually took the first alternative. Yet I have known instances where it became necessary to shut the water out of a ditch and clean out the accumulations of mud and sand in the very midst of a busy irrigating season. The cleaning of large main canals under these conditions is usually done by teams and scrapers; but smaller ditches and farm laterals have to be cleaned with spade or shovel.

It is found necessary to make a spring cleaning of all ditches, so that there may be an unimpeded flow of water from head-gate to termini, in order that a ditch may secure its full legal appropriation, as well as that all patrons may receive the full benefit of their respective water rights. The cost of this cleaning is always an important item in the expense account of care and maintenance, and it sometimes necessitates a special assessment on stockholders, yet it was not until recently that I ever saw any arrangement calculated to obviate the clogging of a ditch from this source.

In the Santa Clara Valley, near San Jose, Cal., a canal which, when run to its full capacity, will irrigate something like 7,000 acres, has been taken from Quito Creek, in order to irrigate the Sorosis fruit farm and quite a large amount of neighboring land. Quito Creek rises in the Santa Cruz Mountains and flows some dozen miles or so through the alluvial plains of the valley before reaching the point where the Sorosis ditch is taken out. During the period of high water the stream carries large quantities of foreign matter, which matter being carried far along the ditch and into the branching laterals, had caused much inconvenience to the irrigators using water therefrom. To obviate these difficulties, Mr. Crandall, manager of the Sorosis farm, made just within the ditch, and beginning at a point as near the headgate as practicable, an excavation conforming with the side lines of the ditch, but deepening gradually on an even grade until a depth of 5 ft. was attained. This depth was attained at a distance of 80 ft. from the point of beginning.

The distant end of the excavation was made perpendicular, the incline being paved with cement and the sides and end faced with 2-in. planks. From this lower end a sluiceway 2 ft. wide and of the same depth as the excavation or settling pool was cut at right angles to the latter, and extended to the bank of the creek for discharge. At the head of the sluiceway a headgate was constructed, which, while the ditch is in operation, is kept closed. From the headgate of the ditch to the lower end of the settling pool, the rate of fall is very slight; in fact it is just as slight as permissible, and allow a flow of the water, so that the water entering from the creek must, for a distance of 80 ft., move at a very slow rate.

It has been found that the water flowing into the ditch and over this comparatively stagnant settling pool deposits within that 80 ft. a very large per cent. of the alluvial matter carried in suspension. Eventually the settling pool becomes filled with these deposits, and then the headgate of the sluiceway is opened and the whole accumulation of sediment is carried in a short time out into the stream, below the main dam of the irrigating ditch. The headgate is then shut down and the current turned back into the ditch. In times of high water and the consequent carrying of larger amounts of sediment the settling pool fills several times every 24 hr., and is as often sluiced out.

Perhaps it would not, in all cases, be possible to apply such an arrangement to an irrigating ditch. The Sorosis ditch is taken out of the Quito Creek above a 14-ft. dam, permitting a sluiceway below of a much greater depth even than that which has been built. Briefly, however, the principal requisite is a sufficient fall for the sluicing away of the deposited sediment from the sand trap or settling pool. Another benefit has been found to be derived from this settling device. A pumping plant used to elevate water for the irrigation of certain lands that are too high to be irrigated from the ditch is supplied from a lateral from the Sorosis ditch. This plant contains a centrifugal pump capable of throwing 5,000 gal. per minute when all conditions are favorable. Before the settling pool was built about two-thirds of the normal efficiency of this pump was lost through clogging by sediment and debris coming in from the creek. The settling operation now enables a large part of this lost efficiency to be regained.

Lower Part of Concrete Footing Enclosing Pile Tops.

Reinforcement Bars Placed in Footing.

A New Form of Primary Contact Bed.

Mr. W. J. Dibdin, to whom is due the use of contact beds for sewage disposal, has introduced an important modification of their construction. Where the beds have been constructed of clinker it has been necessary to renew the filling material at intervals, and it has long been recognized that some construction, yielding an equally satisfactory degree of purification and at the same time securing continuity of working and facility for cleaning the beds without removing the material was desirable. To accomplish this, Mr. Dibdin has employed superposed surfaces, supported by distance pieces, and has found that waste slate is admirably suited for the purpose. At the recent annual meeting of the Association of Municipal and County Engineers, he described this construction and recent experience with it, as follows:

The principle involved is simple. If we imagine the possibility of hollowing out a piece of clinker, and thereby utilizing the otherwise waste space in the interior, it is obvious that we should obtain double surface action, and the hollow interior would hold water, thereby increasing the water capacity.

Such hollow masses could not be obtained conveniently, nor cleansed. As an alternative, we may consider agricultural drain pipes, which would yield the required conditions as to interior surface and space. These pipes, however, would not be economical.

If a pipe is cut down and bent out it assumes the form of a flat plate. The conclusion is that we can arrive at the conditions indicated in the hypothesis of the hollow clinker if we superpose indestructible surfaces separated by suitable distances, thus obtaining the contact action afforded by both the upper and lower surfaces of the plate.

This method was found to answer. After a twelve months' trial on a working scale, the Corporation of Devizes determined to fill the primary contact beds at the reorganized sewage works with slate debris, supported on suitable slate blocks, the distance between the slates being about 2 in.

The advantages of the system are that the extra space available doubles the water capacity, or working power of the bed, and at any time the accumulation of mineral matter, etc., may be flushed from the slates, and the bed restored to its original condition as new.

The detritus washed off the slates was found to dry inoffensively when exposed to the atmosphere, and to assume a condition resembling ordinary mould.

The beds at Devizes have treated the whole of the sewage of that town since September last. The sewage of Devizes is exceptional in nature, in consequence of the large amount of slaughtering which takes place there in the bacon curing and other trades, and it was decided to deal with this highly complex sewage rather than interfere with the various trade interests concerned.

In the Journal of the Society of Chemical Industry for May, 1906, was published a paper read by the author before the Yorkshire section of that society, in which the results of the work done at Devizes were set out in full. It is not to be assumed that no improvement can be introduced in the application of the principle adopted in the first beds constructed to deal with the whole of the unscreened and unsettled sewage by this method. In the meanwhile, the process demonstrates that the natural system of bacterial activity in the presence of a maximum supply of air effects the inoffensive destruction of the solid suspended organic matters in sewage with the maximum of efficiency, and at a minimum cost.

There are, naturally, a few points of detail to be considered in connection with the action of the slate beds. For instance, there are indications that the usual rectangular form of tank might be improved with advantage, as it will probably be found that the residual matters which accumulate in the bed have a tendency to form a natural slope from the sides of the tank to the centre, and it may be a matter for consideration whether this could not be arranged for in the construction of the tank, and so facilitate the process of flushing the deposited matters out when necessary.

It was found that at the end of each discharge from the slate bed a certain quantity of semi-black matter escaped from the outlet, which on examination was found to consist largely of the zooglea form of bacteria with some paper fibres, etc. On being collected on the surface of the fine beds and allowed to drain it rapidly underwent inoffensive decomposition, and dried up into a condition resembling garden mould. The escape of this matter from the slate bed may be looked upon as a satisfactory result, as it necessarily tends to maintain the water capacity of the beds by a self-cleansing process which, coupled with the satisfactory result obtained by the weathering of the matters so discharged, is distinct evidence of the possibility of effecting the inoffensive bacterial destruction of the solid suspended matters in the sewage.

The experience gained in respect to the actual working capacity of the beds was very definite. When the experimental slate bed was constructed at Devizes it was calculated that the actual water content would be 82 per cent. of the total cubic content. By improvements in the arrangement of the slate filling this is now increased to about 87 per cent. After fourteen months' work at about two fillings per day on the average, the water content was measured and found to have decreased 50 per cent. Although it was not necessary to cleanse the tank, so far as the working was concerned, it was considered desirable to ascertain with what facility this could be done in regard to the nature of the deposit on the surface of the slate. Accordingly the bed was flushed out by the double valve being opened to full bore and the contents allowed to rush out, instead of flowing quietly as usual. The capacity was then measured and found to have risen to 64 per cent. Some of the slates were then removed in order to permit sideways flushing through the respective layers of slate by means of a hose; after which the capacity was found to have increased to 82 per cent., exactly equal to the original capacity of the new bed as calculated from the quantity of slate used. The Corporation of Trowbridge having inspected the works at Devizes decided to institute a series of independent experiments, with the view of ascertaining how far the system of slate layers was applicable to the treatment of the effluent from the septic tank into which they propose to pump all the sewage, more particularly for the purpose of securing a good mixing action in consequence of the large proportion of manufacturing waste liquors arriving at the works.

They accordingly prepared experimental beds filled with 1, slate; 2, limestone; 3, broken brick; 4, empty; 5, Westbury slag; 6, clinker.

The sewage, after twenty-four hours' rest in the septic tank, was passed on to the contact beds, and samples of the sewage and various effluents forwarded to Mr. Charles J. Waterfall, of Bristol, to whom, and as well as to the Corporation of Trowbridge, I am indebted for permission to quote the following results from his report thereon:

The result of analysis of the effluents shows the following albuminoid ammonia figures, also per cent. purification:

	Parts per 100,000 albuminoid ammonia.	Per cent purification on septic tank effluent.	Corrected (arbitrary per cent.) for comparison only.
Sewage	1.00	—	—
Septic tank...	0.82	—	—
Slate	0.51	38	60
Limestone ...	0.54	34	35
Brick	0.51	38	41
Slag	0.56	32	22
Clinker	0.48	41	46

The beds when full take the following number of inches of effluent from the septic tank:

No. 1. Slate	6½
2. Limestone	4¼
3. Brick	4½
————	—
5. Slag	4⅛
6. Clinker	4⅝

Taking the slag bed as minimum, I arrive at the foregoing corrected figures.

If we take the results of the last three series only, since the tanks and beds have been in good working order, we obtain somewhat different figures:

	Per cent. purification.	Corrected ditto.
Slate	52 per cent.	82
Limestone	47 "	48
Brick	35 "	38
Slag	32 "	32
Clinker	45 "	50

It will be seen that in either case slate gives the best results; and in the latter series limestone gives nearly as good results as clinker.

As regards silting up, there is some difference between the beds as measured by the number of inches of effluent delivered from the septic tank necessary to fill the contact beds after working for three months, as compared with the amount required to fill the same when first started:

Slate	3-16 in.
Limestone	1-16-in.
Brick	nil
Slag	2-16-in.
Clinker	1-16-in.

In conclusion, I am of opinion that you may safely use limestone for filling your primary contact beds. The results that the limestone gives, particularly in the last series of tests, show it to be a useful material for the above purpose. The slate gives excellent results, and speaks for itself, but the question of cost, which is outside my immediate province, must guide you between slate, limestone and clinker. I must add a word of thanks to Messrs. Stanley and Cole for their kind co-operation in the above experiments.

Experience with the system is also being gained at High Wycombe, where Mr. T. J. Rushbrooke is carefully watching the two experimental beds, which are giving decidedly satisfactory results, and, in conjunction with the experience gained at Devizes and Trowbridge, justifies the theoretical deduction upon which, as already explained, the system is based.

Oiling Roadbeds in Brooklyn.

In order to prevent dust on its suburban surface lines, the Brooklyn Rapid Transit Co. has recently sprinkled a considerable mileage of its suburban lines with crude oil. The suburban lines operated by this company are former steam roads with private rights-of-way, on which is carried during the summer season a heavy excursion traffic between New York City and the ocean resorts where the dust nuisance is a serious objection. About sixteen miles of these lines, all double track, making 32 miles of single track, have been sprinkled with oil.

The oil used for this purpose was a low grade of crude petroleum costing about 3 cents per gallon. Approximately 2,000 gal. were used per mile of track or 4,000 gal. per mile of double track. The oil was received in standard railroad tank cars from the Gulf Refining Co., of New York, these cars being utilized as distributing reservoirs from which the oil was drawn in sprinkling the roadbed. The oil used is one of the very lowest grades, practice in this method of dust prevention having indicated that an oil least desirable for refining purposes is the most desirable for sprinkling on roadbeds, for the reason that such an oil has a large amount of asphalt products which make refining very difficult, but, on the other hand, have an important value as a cementing agency in binding the sand and dust of the roadbed.

The sprinkling equipment was very easily improvised from a motor flat-car of the company's electric rolling stock. This motor car hauled the tank cars in which the oil was received, and also carried the sprinkler piping by which the oil was delivered to the roadbed. The latter consisted of a section of 3½-in. hose which was carried from the outlet opening underneath the tank car, up and along the side of the car to the end nearer the motor flat-car, and thence across to the sprinkler piping, the flexibility of the hose permitting curves to be passed without difficulty. The sprinkling was accomplished through two sections of 2-in. pipe, with low narrow holes, which are hung transversely underneath the motor car body, each section being supplied by a 3-in. branch from the hose supply line. The two sections of sprinkler pipe are each valved for independent operation, one section being so located underneath the car as to sprinkle only to a distance 3 ft. 9 in. on either side of the center of the track, while the other covers the outer portions of the roadbed from these points to points 7 ft. distant from the center of the track on either side. The latter sprinkler sections which overhang some 3 ft. on either side of the car are mounted upon swiveling connections and fitted with handles so as to permit them to be swung out of the way of obstructions at the side when necessary. Both sections of sprinkler pipe are operated by a 3-in. lever gate valve, the handles of the valves being conveniently mounted by a framework above the middle of the car platform.

Special precautions were taken to prevent oil from getting on the running rails, which would result in seriously delaying train movements. For this purpose rail guards are provided which consist of metal shields with the ends slightly rounded up, and to the sides of which are attached pieces of leather which hang somewhat below the head of the rail on either side. They thus serve to drain all the oil off to the sides of the rail, the leather flaps preventing splashing on the rail. These shields were strongly braced from the underframing of the car to prevent injury to the sprinkler pipe in case of meeting possible obstruction.

The results of the sprinkling process have been very satisfactory, the oil having cemented the dust and sand into a semi-solid mass from which practically no dust is generated by trains passing at high speed. The dust nuisance is one that had proven particularly objectionable on these lines of the company prior to oiling, owing to the large proportions of sand in the soil of the roadbed, and to the excursion nature of the traffic. The result of the oiling on the mechanical equipment of trains has been highly beneficial, considerably less dust having been found to accumulate upon the motors of trains operating over these divisions. The growth of vegetation has also been almost completely checked on the roadbed that has been oiled.

Lowering a Masonry Dock Sill practically without interference with the traffic over the sill was recently accomplished at Grimsby, England, by boring holes in the masonry and then breaking the latter in pieces with hydraulic jacks. The sill was for a lock at the outer end of a slip serving about 50 acres of docks, the maximum depth of water over it being about 22 ft., which depth was increased to 26 ft. The bottom of the slip was mud that could be dredged out without difficulty. A cofferdam around the sill which would have permitted the removal of the latter in the dry would have cut off temporarily all of the docks, so the method of boring the masonry and then breaking it with the jacks was adopted. The contract under which the work was done required that no explosives be used and that while the work was in progress shipping should be able to pass freely in and out of the slip from one hour before to one hour after high tide. A boring machine was mounted on wheels on a light, removable gantry spanning the slip. The boring tool used was a steel tube 17¾ in. in diameter inside and ⅜ in. thick. The construction and operation of this tool and the boring machine were almost exactly the same as those of the rotary boring machine made by the American Well Works, of Aurora, Ill., which machine was fully described in The Engineering Record for June 30, 1906. Just 100 separate holes, varying from 2.25 to 7 ft. deep, were bored according to Engineering in the masonry sill of the lock with one boring tool. A solid core, with a diameter slightly less than the tube, was removed from each hole and the drum of a hydraulic jack inserted in the hole to break off the masonry, of which nearly 10,000 cu. ft. were removed.

The Reconstruction of the Cairo Division of the Cleveland, Cincinnati, Chicago & St. Louis R. R.

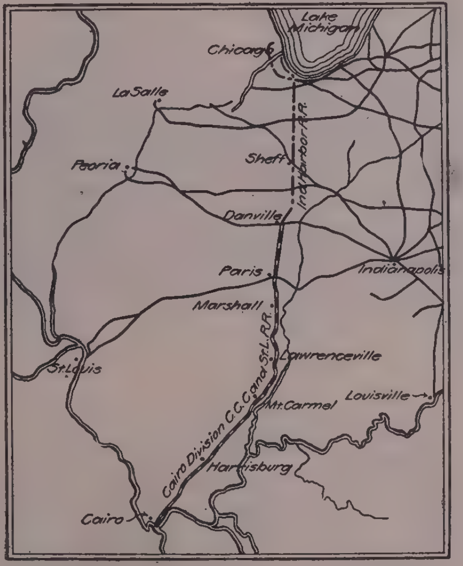
The Cairo division of the Cleveland, Cincinnati, Chicago & St. Louis R. R., extending from Danville to Cairo, Ill., is being entirely reconstructed from Danville to Harrisburg, a distance of 198 miles. This division was made up of a number of independent short railroads that were all built prior to 1880. It formerly had its northern terminus at Tilton, three miles south of Danville, traffic being handled between Danville and Tilton over the tracks of the Wabash R. R. The division crosses the St. Louis division of the Cleveland, Cincinnati, Chicago & St. Louis R. R. at Paris and connects with the Peoria & Eastern division of that road at Danville. Owing to the lack of a direct outlet to Chicago and the north over Vanderbilt lines, the division has never handled the amount of through traffic that might otherwise have been carried over it.

In 1905 the Indiana Harbor R. R., which together with the Indiana, Illinois & Iowa R. R. now comprises the Chicago, Indiana & Southern R. R., was extended 108 miles to Danville from Indiana Harbor on the shore of Lake Michigan, 19 miles south of Chicago. At the same time the Cairo division was extended from Tilton to Danville, forming a direct outlet to Chicago and the north for that division as well as a connection for it with the east and west trunk lines of the Vanderbilt system. Both the Cairo division and the Indiana Harvor-Danville line reach extensive bituminous coal fields, which will not only contribute a large amount of traffic to these lines, but will also supply a large portion of the coal required by the lines of the Vanderbilt system running east out of Chicago. These two lines also provide a direct connection between Cairo and Chicago for the lines of the Vanderbilt system, which will enable that system to be a strong competitor for traffic to and from New Orleans and other ports on the Gulf of Mexico.

The extension of the Indiana Harbor R. R. to Danville is to be a double-track line throughout, with a maximum grade on the north-bound track of 12.5 ft. to the mile, and a maximum grade on the south-bound track of 18 ft. to the mile. The maximum degree of curvature on this line is 1 deg. and the total curvature in the entire 108 miles is about 220 deg., of which nearly 106 deg. were required in the last 4½ miles entering Danville. On an average 40,000 cu. yd. of material were moved to the mile and 40,000 cu. yd. of concrete were required for bridge structures in building this line. All of this work was practically completed in 7 months after the extension was started. A full description of this extension and the methods followed in its construction was published in The Engineering Record for Sept. 30, 1905.

The various independent short railroads that were grouped together to form the Cairo division were built at a time when directness of route was secondary to the possibility of reaching towns that would be a source of traffic, or that might ever become a source of traffic. These roads were also built with little regard for alignment and grades, with the result that many sharp curves and steep grades were included in them. Few of these sharp curves and heavy grades had ever been eliminated even after the combined short roads became the Cairo division of the Cleveland, Cincinnati, Chicago & St. Louis R. R., because the traffic over the division never justified any extensive improvements. The track of the Cairo division is said to have contained practically every weight of rail that is in use in this country and was wholly without ballast in many places. The bridges were nearly all timber structures, a few of the crossings of larger streams being made on steel trusses on masonry footings. The locomotives and other rolling stock of the division, at the same time, were not capable of handling additional traffic.

A number of recent developments in traffic conditions and in railroad extensions in the Middle West were considered to justify the complete reconstruction of the Cairo division and its extension from Tilton to Danville. The unusually rapid increase during the last few years in the output of the coal fields of Indiana and Illinois and the construction of a number of immense tidewater freight terminals at various ports along the Gulf of Mexico, together with the extension of the lines of several large railroad systems to these ports, are, perhaps, the chief reasons which made the complete reconstruction of this division feasible. A heavy traffic can be handled economically after the reconstruction of the division has been completed. For the present a single track will be laid. The maximum north-bound grade on this track will be 0.3 per cent. and the maximum south-bound grade, 0.5 per cent. The maximum degree of curvature is to be 2 deg. The track is being laid with 80-lb. rails and will be gravel ballasted throughout. The old timber bridges are being replaced with concrete or steel structures. The division shops at Mt. Carmel are being rebuilt and more than doubled in capacity, and additions are to be made to the motive power equipment of the division when the reconstruction is completed.



Cairo Division and Vanderbilt Connections.

An immense amount of work is being required to bring the division up to the standards of grade, alignment and construction that have been established. A considerable percentage of the old right-of-way has been abandoned and in a few instances towns that were formerly on the old line are now left to one side. Most of the reconstruction where the old right-of-way has been followed has been done by offsetting from the original track and maintaining traffic on that track until a track over the new work could be made ready for service. Slight changes in grade or alignment, however, have been made on the old track under traffic.

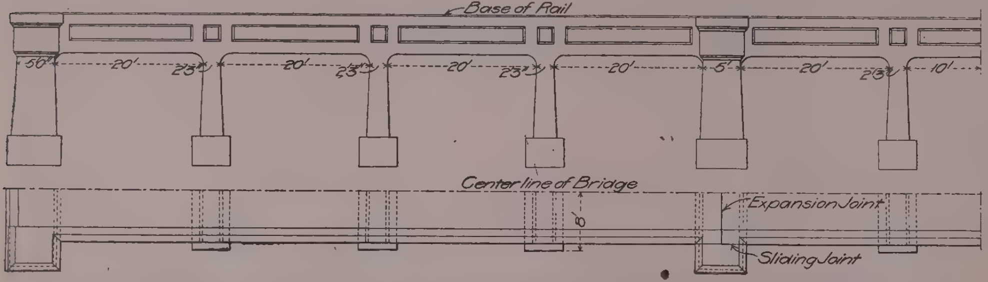
The extension from Tilton to Danville is 3½ miles long and will have two tracks. The construction of this extension involved some of the heaviest work that has been undertaken in rebuilding the division, approximately 500,000 cu. yd. of material being handled in this 3½ miles. This construction was fully described in this journal in the article on the Indiana Harbor R. R. referred to above. The connection between the two divisions is made a short distance east of the North Fork of the Vermilion River on a fill 65 ft. high. The Peoria & Eastern division runs east and west at this junction and the Cairo division extension from Tilton parallels it to the west over the North Fork, the crossing of the stream being made on a pair of 50-ft. concrete arches. The extension then turns to the south and crosses the valley of the Salt Fork of the Vermilion River. This valley is 2,000 ft. wide, with a maximum depth of 95 ft. below the maximum grade line. A fill containing 300,000 cu. yd. of material has been made across this valley from a timber trestle 2,000 ft. long, which had a maximum height of 90 ft. The stream is carried through the fill by a reinforced-concrete bridge structure, which has a 100-ft. and two 80-ft. arches. The design and construction of this bridge structure were described in detail in The Engineering Record for March 3, 1906.

The fill across this valley has been made with material from a 130,000 cu. yd. cut on the Peoria & Eastern division just west of the junction and from heavy cuts on the extension to the south of the bridge. This material was all excavated by steam shovels, hauled out on the trestle in standard-gauge flat cars and dumped from the latter. The high fill was made in this manner without any difficulty in keeping the trestle in line until the fill had been brought up far enough to steady it. After the fill had been completed about 4 months a portion of it suddenly settled several feet due to the toe of the slopes sliding on the surface of a stratum of soapstone that is a few feet below the natural ground surface on which the fill is made. These slopes have now secured a good footing and it is believed no further difficulty will be experienced.

About 1 mile south of Tilton, at Lyons, a gravity freight handling yard is being built. This yard will have 8 miles of track and a capacity of 2,500 cars. It is being built for both storage and classification and all of the traffic on the division will be handled through it. Fourteen miles south of this yard, at Woodyard, a relocation involving about 2 miles of new line is being made to rectify the alignment and to avoid several sharp curves on the old track. From the south end of this relocation nearly to Paris in a distance of a little more than 25 miles the country is quite level and the old line has been closely followed practically all the way. Some comparatively small fills and cuts have been made in this distance to reduce the grades to the established maximums. A number of reinforced-concrete structures have also been built, including some flat-top reinforced-concrete waterways, where headroom is limited, and several 15 to 25-ft. concrete arches. The roadbed has already nearly all been rebuilt in this 25 miles and the track has been relaid with 80-lb. rails and ballasted with gravel.

The country is rough and rolling in the first 18 miles south of Paris to a point 1 mile below Marshall. The old road across this rough stretch had apparently been built without regard for grades or alignment, so that it has largely been abandoned and a new road built which avoids four sharp curves on the old line and is as much as 2¼ miles from the latter places. Just south of Paris, a 140,000-cu. yd. cut is being made through a summit. The material from this cut is excavated by steam shovels and part of it hauled in 5-yd. standard-gauge dump cars to make a fill containing 80,000 cu. yd. to the north of Paris. The total cutting on this relocation amounts to 247,000 cu. yd. and the filling to 237,000 cu. yd.

The old road formerly crossed Big Creek, 2 miles north of Marshall, on a long high wooden trestle that has occasioned much trouble to maintain. The road was also built down one of the principal streets of Marshall, a number of sharp curves being involved getting in and out of the town. The new line is about ¾ mile east of the old line at the town. Big Creek will be crossed on a reinforced-concrete bridge having a 100-ft. and two 80-ft. arch spans; this structure is almost a duplicate of the bridge over the Salt Fork of the Vermilion River at Danville. It is not quite so high above the bed of the stream as that bridge, but otherwise the difference in the design of the two structures is slight. This bridge is being built by the Collier Bridge Co., of Indianapolis, Ind., and is about two-thirds completed. An underground crossing of the Vandalia R. R., which involves a long heavy cut, is being made near the south end of the cut-off around Marshall.



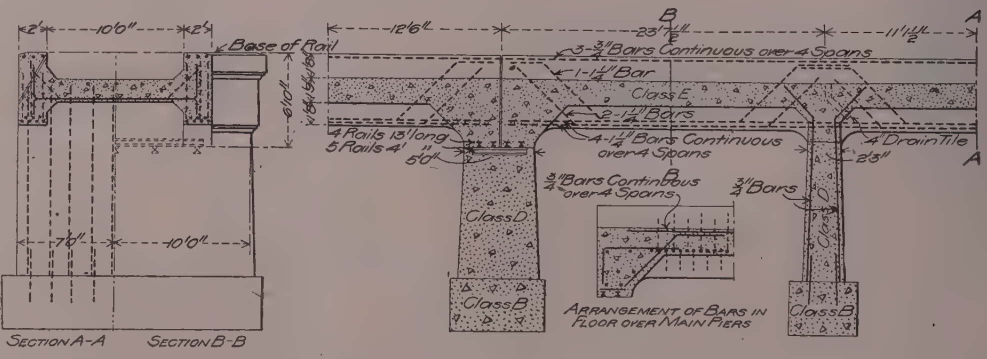
Part Elevation and Part Plan of Trestle in Lawrenceville Bottoms.

One of the Long Reinforced-Concrete Trestles in the Line across the Lawrenceville Bottoms.

In the first 6 miles south of the point where the cut-off around Marshall joins the old line again not much grading work is involved. From the end of this 6 miles of lighter work at Snyder nearly to Robinson, in a distance of 20 miles, the amount of material that has to be moved is large, although the old track is closely paralleled. A fill ½ mile long, which contains about 12,000 cu. yd. of material and is 30 ft. above the old line in places has just been completed south of Snyder. This fill was partially made by teams and scrapers and the remainder with material from a cut to the south with narrow-gauge dump cars operated in connection with a 60-ton Bucyrus steam shovel in the cut. A 100-ft. plate-girder span on concrete abutments carries the new track over Snyder Creek near one end of this fill. One and one-half miles south of this fill at Walnut Prairie is another heavy fill ½ mile long, which contains 60,000 cu. yd. of material that was obtained from a cut to the north.

A large gravel pit has been opened up by the railroad company at West York, 15 miles south of Marshall. The portions of the division that have been reconstructed already have been ballasted with gravel from this pit, and it is the intention to use gravel from the same source in ballasting the remainder of the work as it is completed. The gravel is covered in the pit by a layer of soil, 3 to 15 ft. thick. This soil is stripped from the gravel with a New Era grading machine and is loaded into standard-gauge side-dump cars and used for filling along the line. The gravel is excavated with steam shovels and is also handled in the standard-gauge side-dump and Rogers ballast cars. About 300,000 cu. yd. of gravel have been removed from this pit since the reconstruction of the division was commenced.

The work required to reduce the grades in the vicinity of this pit is heavy. Just below the pit the line crosses Raccoon Creek on a steel bridge, having an 85-ft. and two 45-ft. deck plate-girder spans on concrete abutments. A relocation 9 miles long is being made just south of this bridge from Robinson to Flatrock. For about 15 miles south of the gravel pit a number of changes have been made in the grades, including the 9-mile relocation, but little heavy work has been done. A cut containing 38,000 cu. yd., with a fill on each side, has been made to reduce the grades over a summit at the end of this light work, north of Birds.



Details of Reinforced-Concrete Trestles in Lawrenceville Bottoms.

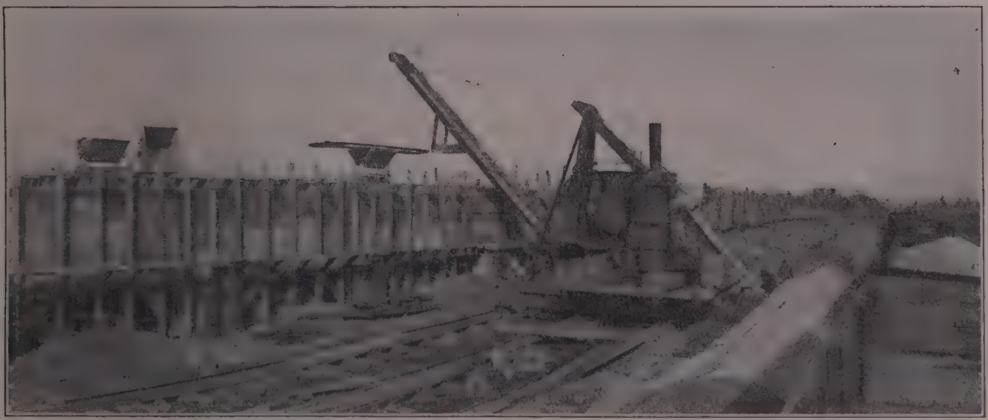
The next work of any importance is a 3½-mile relocation across the bottom land along the Embarras River, just north of Lawrenceville. The old track across these bottoms, by swinging to one side from a direct line between a river crossing on one side and the track on high ground on the other side of the bottoms, involves two sharp curves. The Embarras River empties into the Wabash River a short distance below the river crossing and under certain conditions the back water from these streams floods the bottoms, the result being that the old track has been covered with water a number of times. The track of the relocation will be on embankments 10 to 18 ft. above the general ground level, which will place it well above the maximum flood heights. These embankments have all been made with teams and wheel scrapers from borrow pits along each side of them. These borrow pits have been excavated in such a manner that they form drainage canals for these bottom lands and will be of considerable advantage in lowering the ground water level in the land.

Two reinforced-concrete trestles have been built in this embankment to provide waterways through the latter. One of these trestles has forty-eight 20-ft. spans and is 1,126 ft. long; the other has twenty-four 20-ft. spans and is 596 ft. long. The details of both of these trestles are the same and are shown in the accompanying reproductions of the plans. Each trestle is divided into sections consisting of four spans. The end piers and every fourth pier from them are considerably heavier than the intermediate piers. The floor slab has a clear width of 14 ft. and is carried between the piers by a 2-ft.x5-ft. 4-in. reinforced-concrete girder on each side. It is in sections extending from the transverse center line of one large pier to the transverse center line of the next large pier. The sections of the slab are anchored to the intermediate piers by ¾-in. bars, placed 18-in. apart on centers near both sides of the piers and extending from the footings of the latter into the floor slab.

An expansion joint is made over the main piers between the ends of the four span floor-slab sections. A sliding joint is made between the ends of the slabs and the inner face of low head walls on the ends of these main piers. A pressure joint is also provided between the bottom of the end of each section of the floor slab and the top of the main piers, where the former has bearing on the latter. The concrete surfaces at the expansion and sliding joints were finished smooth and flat, then two layers of felt were placed in the joint and carried up to within 2 in. of the top of the joint, the remaining 2 in. being filled with concrete. In the pressure joint sections of railroad rails, 4 ft. long, were placed parallel to the center line of the bridge and 3 ft. apart on centers in the top of each main pier. Two 13-ft. lengths of rail were placed in the bottom of the end of each floor slab section, transversely to the pieces of rail in the top of the piers. The ball of the rails in the top of the piers was placed up and that of the rails in the bottom of the slab down. In both cases, the ball of the rails extends ⅛ in. from the surface of the concrete, which was given a smooth, flat finish so that contact is made only at the rails. Two layers of felt were also placed between the concrete surfaces in these pressure joints. In all cases the felt in the joint was given a slight lap so that it would not be broken by the movement of the floor slabs due to expansion and contraction.

These two concrete trestles were built by the Moore-Mansfield Construction Co., of Indianapolis, Ind., which company designed and erected a traveling concrete mixing plant that was found to be particularly well adapted to the construction of the trestles. This plant consisted essentially of a tight timber platform carrying a Smith concrete mixer, a hoisting engine and a boiler to supply steam to this engine and to the engine of the concrete mixer. This platform was mounted on nine double-flanged traveler wheels running on three lines of rails laid parallel to the concrete structures. A railroad siding was extended from the old main line track to the two structures, and then parallel to the latter with sufficient room between the siding and the structures for storing materials for a tramway material track, and for the three lines of rails on which the traveler was moved along as the work progressed.

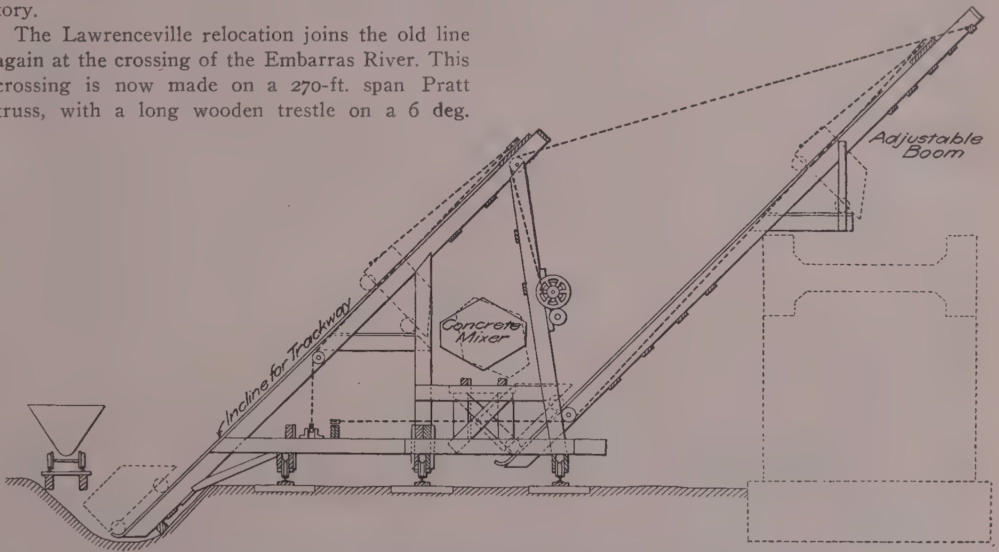
The concrete materials were unloaded from cars on the siding into separate classes which were then loaded as required into small dump cars on the tramway in the proper proportions for the concrete. The traveler platform carried an inclined frame extending from a pit at the side of the tramway track and at the rear of the platform up to a point above the mixer, as shown in the accompanying illustrations. Skip cars were operated up and down on a track on this incline by the hoisting engine. The cars on the tramway dumped the concrete materials directly into these skip cars, which were hoisted up the incline and dumped into the mixer. An adjustable boom, carrying a track, extended from the front of the platform over the site of the structure. The concrete was discharged from the mixer into skips on the track on this boom; these skips were hoisted up on the boom and the concrete dumped automatically from them into dump cars running on a track laid longitudinally on top of the form work for the structure. These cars were then pushed to the desired position and dumped. The boom at the front of the platform was made adjustable to provide for the difference in the level of the ground along the structure. In the accompanying reproduction of a photograph of the plant in operation the boom is elevated while the plant is being moved to the next section. A section of 4 spans was built from a single setting of the mixing plant, then the latter was moved forward and another four-span section built. The skips were handled on the incline and boom by a 16-h.-p. hoisting engine. The dump and skip cars were built by the Arthur Koppel Co.



Concrete Mixing Plant Employed in Construction of Reinforced-Concrete Trestles.

When the plant was constructed the expectation was to use it in mixing and placing the concrete for the footings of the two concrete structures as well as for their superstructure. The plan was to lay a longitudinal tramway between the site of the structures and the plant so that the mixer could dump into cars on the tramway. These cars could then be hauled ahead and concrete supplied for work on the footing simultaneous with work at the plant on the superstructure. A portable mixer driven by a gasoline engine was available, however, so the concrete for the footings was mixed in it and the large plant confined to work on the piers, girders and floors, on which work it proved very satisfactory.

The Lawrenceville relocation joins the old line again at the crossing of the Embarras River. This crossing is now made on a 270-ft. span Pratt truss, with a long wooden trestle on a 6 deg. curve at one end. The relocation cuts out this curve. The steel span will have to be removed a few inches only and four 64-ft. plate-girder spans will be added at one end of it to replace the wooden trestle.



Diagrammatic Cross-Section of Concrete Mixing Plant.

A cut will be made through Lawrenceville just south of this river crossing. A cut-off, 1.53 miles long, is started just south of this cut through Lawrenceville. Beyond the junction of this cut-off with the main line again the work is light, consisting for 5 miles mostly of alteration of grades on the old track.

At the end of this 5 miles is a 3½-mile relocation around St. Francisville. The old track curves around the end of a long rolling hill back of this town and contains 4 curves and 2 long grades that are eliminated by the relocation. A cut about 1 mile long, which is being made for two tracks and contains a large amount of material, is nearly completed through the long hill on this relocation. The material has been excavated from this cut by 2 steam shovels and has been used in making fills in the vicinity. A 10-mile branch of the division extends from St. Francisville to Vincennes, Ind. The relocation required an extension of this branch to the new work across a creek valley in which a fill upwards of 35 ft. high, and 1,500 ft. long had to be made.

Six miles south of St. Francisville at Allendale a long cut has been made through a summit to reduce two heavy grades. An overhead reinforced-concrete highway bridge has been built across this cut. This bridge has a 35-ft. span over the two tracks in the cut and clears the tracks 22.5 ft., with two 18-ft. spans on each side of this 35-ft. span. The two spans on each end of the bridge are both on a 5 per cent. ascending grade but the center span is level. The bridge has a 16-ft. roadway with a low curb on each side. The floor slab of the bridge is continuous and is carried between the piers by 3 longitudinal reinforced-concrete girders, one at the middle and one on each side of the slab. The slab is reinforced transversely between these girders by ¾-in. Johnson corrugated bars, placed 12 in. apart on centers and extending from the girder on one side to the girder on the other side. It is also reinforced longitudinally from pier to pier by ¾-in. Johnson corrugated bars, spaced as shown in one of the accompanying illustrations. A number of structures of this same type have recently been built by the Cleveland, Cincinnati, Chicago & St. Louis R. R., among which are two on the Hillsboro-Mitchell cut-off on the St. Louis division. A similar crossing is being built on the extension of the division, just south of Danville.

The division shops are at Mt. Carmel, 15 miles south of St. Francisville. A new 120-ton electrically-operated locomotive coaling station has recently been completed in connection with these shops by Fairbanks, Morse & Co., of Chicago. An addition to the engine house is just being completed so that stall room will be provided for 20 engines at the shops. A 27x60-ft. brick building for a smith shop is being added to the machine shop. The ground on which this addition is being erected is of such uncertain character that 150 concrete piles, built by the Raymond Concrete Pile Co., were placed to carry it. A 62x127-ft. brick building is being erected for a wood working shop. A 98x225 ft. erecting shop, with a 15-ton and a 100-ton crane, is being completed. The old shops are also to be completely overhauled and the yards around them relocated.

The Southern R. R. crosses the tracks of the division just south of these shops. Below this crossing a classification and storage yard 2 miles long is being laid out. One end of this yard requires a fill over ½ mile long, which is being made wide enough for 14 tracks. A cut 1 mile long, that contains about 300,000 cu. yd., is being made at the south end of this yard. A flat-top reinforced-concrete culvert with two 18-ft. spans will carry a waterway through the fill at the north end of the yard. This culvert will have a total length of 202 ft. and will carry 15 tracks. It will require 5,000 cu. yd. of concrete and 72 tons of reinforcing metal, Johnson corrugated bars being used for reinforcement. A large number of flat-top culverts of this same type, having one, two or three spans have been included in the reconstruction work.

The waterway which passes through this culvert has a heavy flow of water under certain conditions and carries considerable drift. For those reasons, the centers that carry the forming are built as trusses and are independent of any falsework erected in the waterway. The trusses are carried entirely by the bench walls of the flat tops of the spans and the footings of those walls. The details of these trusses are shown in an accompanying illustration. The trusses are built so they can be erected practically without nails. The two blocks at the points marked B and the two at the points marked C are nailed to the main timbers, but otherwise no nails are used. The forms for the flat slab of the culvert top are built in three longitudinal sections, one section for the flat portion of bottom of the slab of the span, and one for the inclined fillet at each side of the slab. These trusses are placed 3 ft. apart on centers. They are removed by knocking out wedges between the two inclined chords at the point marked A and are used repeatedly. The trusses consist of 6x6-in. timbers and the forms of 2x10-in. plank.

The concrete is all mixed by hand on platforms directly over the point where work is in progress, as the length of haul of materials necessitated does not permit machine mixing to be done economically. The construction was started early in December last, and was carried on during the entire winter, high water greatly retarding the progress. No concrete work was done when the temperature of the air was below 20° Fahr. The water and gravel used in the concrete were heated and salt was added to the water when the temperature was between 20° and 32° Fahr. Precautions were also taken to protect the freshly laid concrete when the temperature was below freezing point.

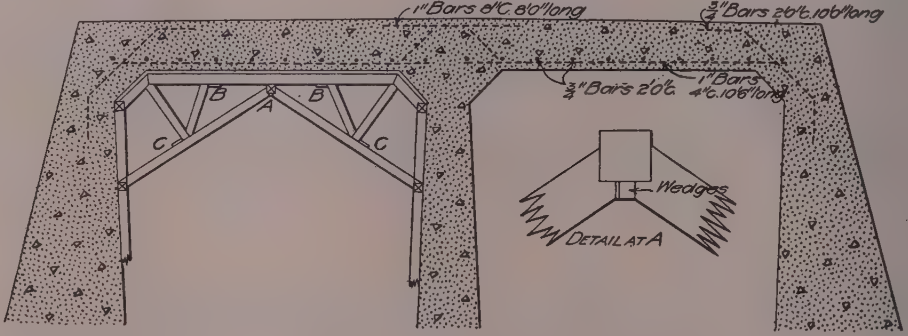
The exposed surfaces of concrete are carefully finished by rubbing. As soon as the forms have been removed the irregularities are rubbed off with a wooden float and the hollow spaces filled with mortar. When the concrete has aged a little longer, it is wet and scoured with wooden floats and rags, flushing the mortar to the surface. The surface is finally gone over with a piece of clean white limestone which imparts to it a nearly white uniform finish.

For 15 miles south of the yard at Mt. Carmel to Grayville the country is a succession of long rolls, over or around which the old road was built. The curves and grades in this distance will all be reduced to the established standards for the new construction requiring some very heavy grading. North of Grayville the old line followed a circuitous route around a long hill, but even then it encountered two or three heavy grades. A relocation which will require an 80,000-yd. cut in 4,000 ft., with a fill at south end, will be made through this hill.

The largest and most difficult cut on the division is just being finished 6 miles south of the Grayville relocation. This cut is nearly 1 mile long and has already required the removal of over 350,000 cu. yd. of material, although its maximum depth is 50 ft. It was made with two steam shovels through a peculiar kind of joint clay that sluffs off and slides on the slopes of the cut like wet meal. The only manner in which the sides of the cut could be held so as to prevent the tracks in the cut from being covered was to cut a berm 20 ft. wide about half way up on the slope.

The material from this cut was hauled to the south in trains of 5-yd. standard-gauge dump-cars and placed on a fill through Crossville, about 1 mile to the south. This fill is upwards of 2 miles long and has a height of about 25 ft. in most of this distance. Two 20-ft. concrete arches for waterways and four reinforced-concrete undergrade highway crossings have been built through this fill. The design of these highway crossings is similar to that of the 2-span waterway under the yards of Mt. Carmel. Two of the completed structures are shown in accompanying illustrations.

The reconstruction of the division has thus far been put under way only to Harrisburg, 70 miles from Cairo. The principal work that has been done between the heavy fill at Crossville and Harrisburg, in a distance of 40 miles, is a relocation 12 miles long that is about 20 miles north of Harrisburg. This relocation leaves the old line as much as two miles in places and will require the moving of approximately 575,000 cu. yd. of material to complete. A large yard is to be built and a number of improvements are to be made in Harrisburg. Location surveys are being completed for the work between Harrisburg and Cairo. The country for this 60 miles is rough and rocky and will entail expensive work, many of the cuts being through solid rock.



Centering Carried by Bench Walls Used in Building Concrete Culvert.

In the work that has been undertaken to date, the contracts have been awarded for 4,000,000 cu. yd. of grading. The contracts have also already been awarded for 56,000 cu. yd. of concrete. This concrete is made in 5 classes designated as A, B, C, D and E concrete. Classes A and B are used for footings in unexposed situations, or where concrete is required in large masses for weight. Class A consists of 1 part cement, 4 parts sand and 8 parts broken stone; class B, of 1 part cement to 9½ parts gravel. Classes C and D are used in bodies of piers, abutments, side and wing walls of culverts and for general purposes. Class C consists of 1 part cement, 3 parts sand and 6 parts stone; class D consists of 1 part cement to 6½ parts gravel. Classes B and D are substituted for classes A and C respectively where gravel is more easily obtained than broken stone. Class E is used in arch rings, reinforced-concrete beams and culvert covers. It consists of 1 part cement, 2 parts sand and 4 parts broken stone.

Portland cement is used exclusively in all the concrete and is tested according to standard requirements. Clean sand all of which will pass a screen with a ⅜-in. mesh is required, although sand is used if it does not contain more than 3 per cent. of loam or clay. Dust from a rock crusher, with all particles exceeding ¼ in. in diameter screened out is used, if acceptable, instead of sand. Crushed limestone is used in all of the concrete, two sizes being employed. One size is such that every piece will pass through a 2½-in. ring and be retained on a screen with ½-in. meshes. The other size is such that it will all pass through a 1½-in. ring and be retained on a screen with ½-in. meshes. The larger size is used principally in classes A and B concrete, and the smaller size in the other classes. The gravel used is required to be composed of sand and clean, hard, durable pebbles of sizes not exceeding 2 in. in diameter. It must also be free from clay and other impurities. If the ratio of the sand to the coarser particles or stone contained is not as 1 to 2, sand or broken stone are added so the proper proportions may be obtained in the concrete mixture.

The reconstruction of the Cairo division is being carried on under the direction of Mr. W. M. Duane, chief engineer of the Cleveland, Cincinnati, Chicago & St. Louis R. R.; Mr. Duane as superintendent of construction, personally supervised the design of most of the structures that are being built in the reconstruction and also the early field work. Mr. F. W. Smith, as division engineer of the Cairo division, directly supervised the field work until his recent appointment as principal assistant engineer of the Cleveland, Cincinnati, Chicago & St. Louis R. R. Mr. John Hall has been directing the work as division engineer since Mr. Smith's promotion. The principal general contractors other than those previously mentioned are the Oliver Construction Co., of Knoxville, Tenn., and the Walsh Construction Co., of Davenport, Ia. The concrete work has been done largely by the Collier Bridge Co., and the Moore-Mansfield Construction Co., both of Indianapolis, Ind.

A 3,600-H.-P. HYDRO-ELECTRIC GENERATING STATION has recently been completed on the north fork of the San Joaquin River in the Sierra Nevada Mountains, 50 miles northeast of Fresno, Cal., by the San Joaquin Light & Power Co. The conduit supplying water for the operation of the equipment of the station has a total length of 4.3 miles and comprises open canal, tunnels, flumes and a pipe line. These structures are designed for a flow of 100 cu. ft. per second, and, with the total available head of 400 ft., produce a total capacity of 3,600 h.-p. The canal portions of the conduit are 5 ft. wide and 3 ft. deep and are lined throughout with concrete. The intake basin of the conduit and the forebay at the power house are built of concrete. The tunnels of the conduit are also lined with concrete. The flumes are built of ⅛-in. steel plates and are semi-circular, with a width of 6 ft. The pipe line is 3,000 ft. long and 52 in. in diameter, the thickness of the steel plates of which it is built varying from 3/16 to ½-in. The station contains two tangential-type water wheels, each of which drives a standard Allis-Chalmers water-wheel type, 1,000-kw., 550-volt, 3-phase electric generator operating at 300 r.p.m. Two 62½-kw. direct-connected exciters are provided.

Progress on Catskill Water Supply for New York City.

Nearly a year has passed since the chief engineer of the Board of Water Supply of the City of New York and one member of his staff were appointed. Within the year an engineering force of over five hundred members has been organized; headquarters, field offices and a laboratory have been secured and furnished; equipment and supplies for this large force have been purchased; surveys have been made of hundreds of miles of possible aqueduct lines and thousands of acres of topography and real estate; studies for the designs of the most important features of the system have been well advanced; an investigation of materials available for construction has been well started; much information has been collected, and field and office methods have been developed. The very large amount of work and worrisome detail involved in this catalogue can be fully realized only by engineers who have had a leading part in the early stages of some great engineering enterprise under the conditions surrounding public works. This accomplishment is the more noteworthy because the work has been done with commendable thoroughness.

Since this is by far the greatest undertaking of its kind a brief review of the first year's progress in the preliminary work is of special interest. On Aug. 1, 1905, everything was to be gotten, from pencils to corps. Now there are four large, well-organized departments of the engineering bureau. Headquarters department has charge of civil service matters, selection of employees, designs, experimental investigations, purchase of supplies and equipment, tests of materials of construction and miscellaneous executive work relating to the engineering bureau as a whole. Reservoir department, with offices in the Catskill Mountain district, has in hand surveys and construction on the watersheds, beginning with the great Ashokan Reservoir. To the Northern Aqueduct department has been assigned the portion of the 500,000,000-gal. Catskill Aqueduct between Ashokan Reservoir and the Croton watershed, a length of approximately fifty-five miles including the difficult Hudson River crossing and a number of tunnels, some at hydraulic gradient and some under pressures probably considerably in excess of 300 ft. at places. The Southern Aqueduct department has the remaining thirty miles of aqueduct, the very large Kensico storage reservoir and the terminal distributing reservoir at Hill View, on the extreme northerly edge of Greater New York. Two other departments are comprehended in the scheme of the engineering bureau and will be organized when needed, one to have charge of the development of the ground water supply in the easterly portion of Long Island and the other to construct the filtration plant.

The engineer staff is now the largest engineering organization in the service of the city, and probably one of the largest in the employ of any city. A competent observer recently expressed the opinion that it is the finest municipal engineering organization in the world. Be that as it may, great pains, ingenuity and patience have been necessary to secure as needed, under civil service limitations, so large a number of suitable men. Probably more than two thousand persons have been interviewed and corresponded with, some of them several times. Many vexatious delays have been experienced. Several special civil service examinations have been held. Many eligible lists have been exhausted and men have had to be appointed temporarily and then dismissed and others trained to the work when new eligible lists were issued. Already a number of vacancies have occurred and have been filled because good men have been attracted elsewhere by offers of higher salaries.

The proposed works stretch in a continuous line one hundred and fifty miles long from Staten Island to the northerly side of the Catskill Mountains. The surveys have included thousands of feet of wash and diamond drill borings and other explorations of underground conditions at dam sites and along the aqueduct lines. This part of the work has been guided and its results interpreted by expert geologists. The country to be traversed by the aqueduct is of such a nature that an almost endless number of lines or modifications and combinations of lines is possible, and it would take several years of active surveying with a large force to exhaust all these possibilities so as to determine to the last degree of refinement the most economical location. But the expense in money and time, especially the latter, would be prohibitive, and would very likely overbalance any further attainable economy in construction. Sufficient exploring and detail surveying has been done in the limited time at the disposal of the board to determine feasible and economical locations for all parts of the works. The surveys, designs and investigations have progressed so far that one or more very large contracts will be ready for letting before the end of this calendar year.

Special investigations have been undertaken along a number of lines. Hundreds of samples of soil have been collected from the site of the principal reservoir and tested to assist in determining to what extent the bottom shall be stripped. Scores of samples of sand, gravel and broken stone have been gathered along the line of the works and sent to the laboratory, where they are being tested in a variety of ways. Samples of asphalts and other waterproofing substances and a variety of materials of construction are being obtained and tested. An extensive series of experiments on a practical scale has just been inaugurated to aid in deciding the extent to which reinforced concrete pipes of very large diameter can be used under pressure for the inverted siphons, of which many miles are necessary in the aqueduct line. Experiments have been conducted on existing aqueducts to gain information. Filtration of the new supply has received preliminary consideration. Many rain gauges have been established on the watersheds and all available rainfall and stream-flow data having bearing on the yield of these watersheds have been collected and digested. Several sites for the great dams have been and are being carefully examined and studies of different types of dams are in progress.

Since in many parts of the region suitable permanent offices cannot be rented, designs have been drawn for buildings to accommodate the different units of the field forces. A large number of small buildings will have to be erected for this purpose and several of considerable size. Preparations are so far advanced that contracts for a number of these offices can be let early this autumn. A photographic laboratory is being fitted up. Systems for filing and indexing letters, reports, drawings, field notes, computations and photographs and many other details of field and office work have been elaborated. A book of regulations for the guidance of the members of the engineering bureau has been prepared for printing, and has been in use for months in manuscript form. There have been installed complete card systems for keeping detailed records of each employee and of all supplies and equipment. Much special furniture has been designed and obtained at economical figures.

Early in the history of the board, when as yet the engineering staff in field and office was but a handful of men, several large maps, estimates of cost and reports setting forth the proposed system of supply were prepared to accompany the petition to the State Water Supply Commission for the appropriation by the city of Catskill Mountain sources. Many public hearings were held on the application, and for these the engineers prepared numerous diagrams and documents and presented personal testimony. Many special reports have been written.

Reinforced-Concrete Undergrade Highway Crossing in Fill Through Crossville.

AN IMMENSE DRY DOCK is to be built by the Navy Department at the Bremerton Navy Yard, on Puget Sound. The naval appropriation act passed by the last Congress contained a provision for $1,250,000 for this dock, which amount is a larger sum than has ever been appropriated heretofore by the Government for a dock. The new dock will be of concrete, and when completed will be able to take in the largest battleship, either in course of construction or in contemplation.

Concrete Underpinning and Foundation Piles.

The twelve-story and basement steel-cage building for the Richmond Realty & Construction Co. occupies the corner at Twelfth St. and Broadway, New York, and is adjacent on the other two sides to the six-story St. George Hotel, which is L-shaped in plan with fronts on Broadway and Twelfth St. The lot occupied by the new building is not rectangular, its sides varying from 35 to 85 ft. in length. The cellar is excavated to water line at a depth of about 13 ft. below the curb, the soil encountered being sand mixed with loam and some gravel and boulders, as usually found in this locality. The foundations are carried to rock, the surface of which is at an average depth of about 20 ft. below the cellar bottom.

The footings of the adjacent 30-in. brick walls of the St. George Hotel were of rubble masonry about 3 ft. wide and 4 ft. deep, and extended about 10 ft. below the curb. As the excavation was to be made adjacent to these footings and about 5 ft. deeper it was first necessary to underpin them, which was done with steel and concrete piles carried down to rock by the Breuchaud process. The estimated weight of the walls was about 10 tons per lineal foot and their combined length of 85 ft. was carried by fourteen columns each consisting of a 12-in. welded-steel pipe, with inside couplings forced down in the plane of the wall with a water jet and a 100-ton hydraulic jack. After reaching the rock the pipe was washed out, emptied, filled with concrete and wedged against the reaction beams, and the recess in the wall bricked up in the usual manner. This method of underpinning was considered safer and more economical than the use of needle-beams which would seriously obstruct the working space in the new building and require entrance to the hotel basement, which it was difficult to secure. It also permitted the new footings to be easily carried to a depth which would have involved difficult sheeting and costly excavation by the open-trench process. The underpinning was accomplished in 20 working days by two masons, cutting the recesses, and three men operating the jack and jet, besides the men at the pump, and steam boiler.

As it is possible that the ground-water level in this locality may be considerably lowered at some future time, by the construction of subways, deep cellars or other foundations, it was not considered safe to rely on a permanent saturation of wood below the cellar floor, so for that reason wooden piles were excluded. The character and depth of the soil was such that sinking open caissons would have been difficult and expensive, while pneumatic caissons would have been still more costly. It was therefore determined to employ concrete piles which are considered to afford many of the advantages of masonry piers at a much less expense. The foundations were accordingly designed with clusters of piles supporting the footings of the interior columns and continuous staggered double rows for the two walls adjacent to the hotel. The tops of the piles are capped with concrete 30 in. thick, which receives the pedestals or grillages for the superstructure and has the upper surface continuous with the concrete cellar floor.

There are in all 168 piles with an average length of 17 ft. These piles are of the Raymond type, 6 in. in diameter at the point and tapered 1 to 17, an amount which gives them a diameter of 20 in. at the top of a 20-ft. length. This conical shape, although it much increases the difficulty of driving, compacts the soil and is considered to materially augment its bearing power. The pile shells are each made in three telescopic lengths from special No. 20 cold-rolled sheet steel with back-lock joints. The points are inserted in special cylindrical caps 10 in. long and hot-pressed from No. 16 steel by J. W. Wallace, New York. The pile shells are assembled on a collapsible steel mandrel and are driven in an ordinary pile-driver machine with 55-ft. heads. The pile driver is mounted on a turntable beneath which is the ordinary rolling bed frame, so that the machine can easily swing around and drive several piles in a group without much difficulty in moving it.

The leads contain a No. 2 Vulcan steam hammer weighing 6,500 lb. with a 3,000-lb. plunger which strikes an average of 60 blows per minute. From about 360 to 500 blows suffices to drive the piles to bed rock, and the last inch of penetration usually requires from 12 to 25 blows. The piles are driven without jetting and considerable time was lost at the commencement of work by moving the machine to different parts of the lot because conditions did not permit the driving of all the piles in regular order. Under these conditions an average of about 12 piles in a 10-hr. day have been driven by a force of ten men, a record which is only half what has been attained under more favorable conditions. As soon as the mandrel is withdrawn, the pile shell is filled with 1:3:5 Atlas Portland cement concrete mixed by hand and practically shoveled in directly from the mixing platform. The concrete is mixed wet and is thoroughly compacted by falling into the moulds which have been found stiff enough to resist external pressure and retain their shape until the concrete is set.

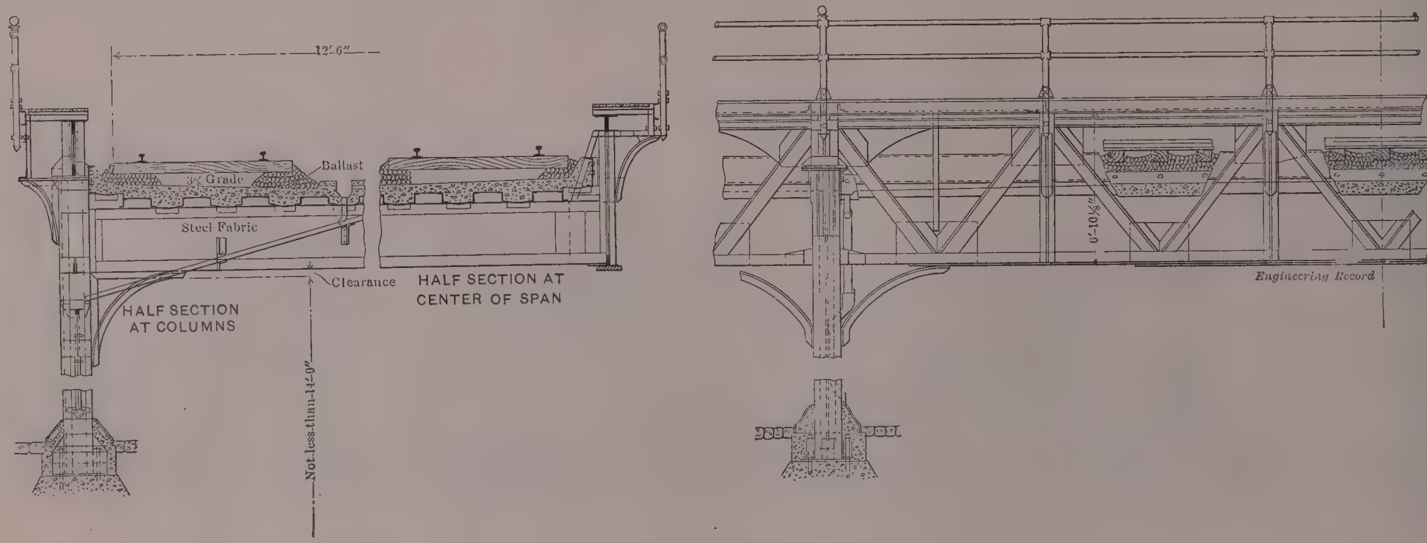
Mr. Samuel Sass is the architect for the building and Mr. T. P. Bryson is the contractor for the substructure. The Raymond Concrete Pile Co. is the contractor for the concrete piles.

The Market Street Elevated Railway, Philadelphia.

The first section of the Philadelphia Rapid Transit Co.'s lines has been constructed and recently put in operation on West Market St. It consists of a four-track subway from the City Hall about 4,145 ft. to the Schuylkill River, in which at this time are operated, a limited number of street cars as preliminary partial service. The double-track steel elevated railway 19,340 ft. long extending about 600 ft. west of 63rd St., in Delaware County. The subway and elevated railway sections are connected by a bridge about 563 ft. long which carries four tracks across the Schuylkill river at two different grades so as to unite the subway with the surface and elevated tracks. The 214½-ft. channel span and the 90 and 98-ft. adjacent spans are riveted through-truss structures and the two end spans are plate-girder structures about 78 ft. and 82 ft. in length, all of them being of special construction to provide for the somewhat unusual arrangement of tracks. The two tracks in the center of the bridge which are to be used for the elevated service ascend to the west on a grade of about 5 per cent. and continue beyond the river on the elevated railway. The two outside tracks now used for local service, are approximately on the level of Market street, and connect west of the bridge with the street railway tracks at the surface of the street.

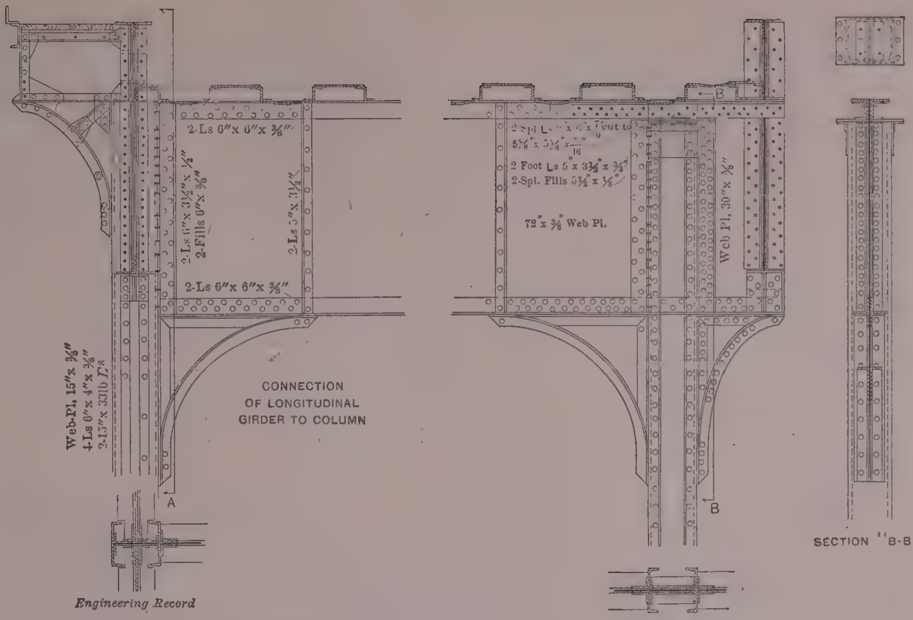
Nearly all of the elevated railroad structure is on a tangent, the axis coincident with the center line of Market St. The maximum grade is 4.5 per cent; the minimum clearance above the street is 14 ft. 1½ in. and the minimum height of rail above the street is 18 ft. 5 in. In general the structure is made with 50-ft. longitudinal latticed girders directly connected to vertical columns 24 ft. apart transversely, with spans in special situations from 50 to 80 ft. long having the columns braced. At the stations, where passages are provided over the street, under the tracks, with the consequent increased elevation of the structure, longitudinal bracing is afforded by the use of deep latticed trusses.

At the river end where the tracks form a reversed curve to follow the offset in the alignment of the street, there are seven spans of plate girders from about 30 to 60 ft. in length. The lengths of the spans and the arrangement of the columns is varied in a number of places on account of the clearance required for the cross streets and for the location of the stations which are generally about four blocks apart and which are supported on girders independent of the railway girders so as to avoid as much as possible the transmission of train vibrations.

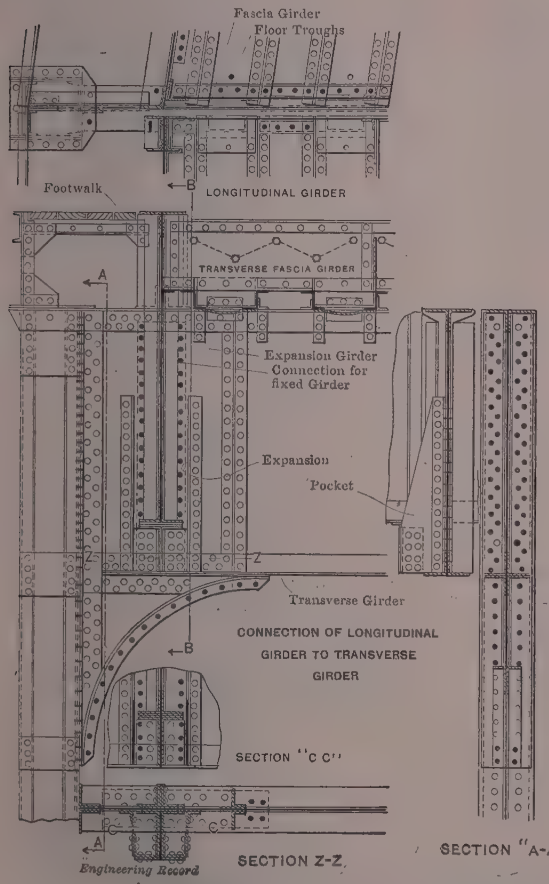


General Transverse and Longitudinal Elevations of Regular Spans.

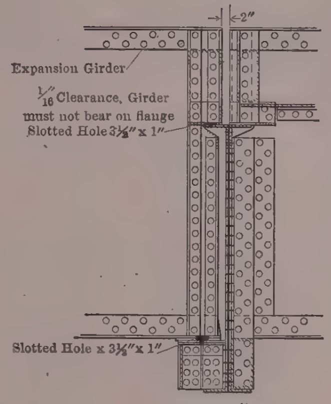
The construction may be divided in a general way into three types, first, the regular construction with 50-ft. longitudinal girders about 7 ft. deep over all which is used for about 17,908 linear feet; second, about 517 linear feet of the deep span construction near the stations made with 50-ft. longitudinal girders about 15 ft. deep; the third about 325 linear feet of plate girder construction. Up to the Delaware County line, a distance of 18,750 ft. the city ordinance required the construction of a solid floor which would intercept all leakage and drip; beyond that point in Delaware County, the ordinary open floor construction with cross ties laid on the top of flanges of the longitudinal girders has been employed for a distance of 680 ft. to the abutment at the end of the solid filled structure between retaining walls.



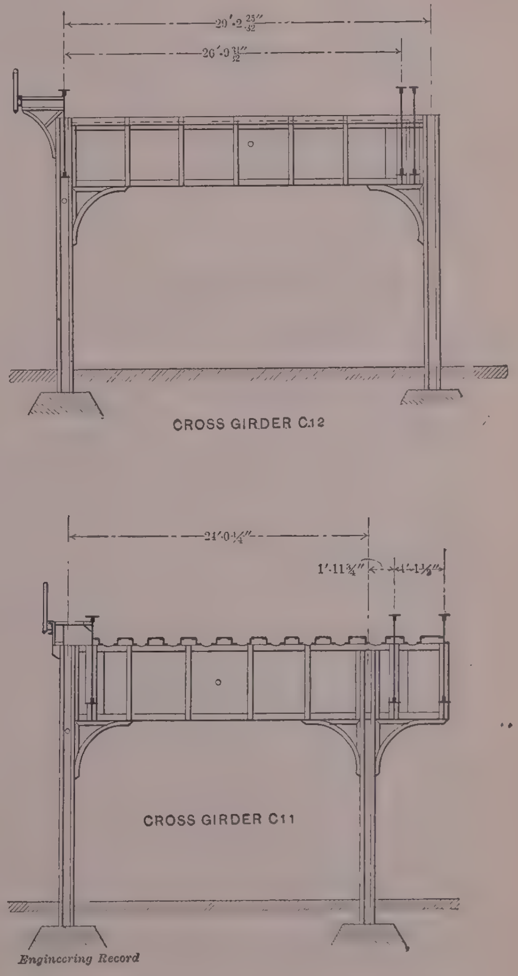
Details of Column and Girder Connections.



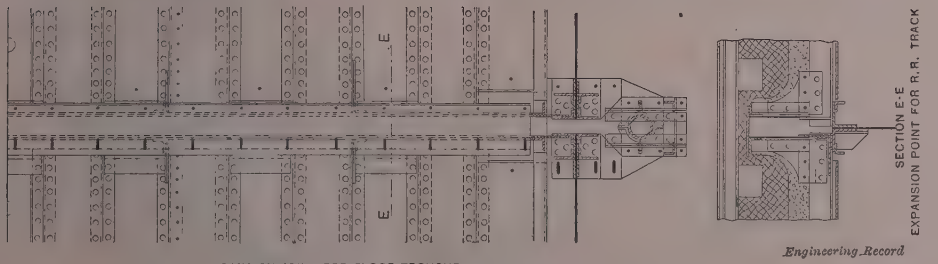
Expansion Connection of Longitudinal Plate Girders.



SECTION "B-B"



Typical Arrangement of Plate Girder Construction.



EXPANSION JOINT FOR FLOOR TROUGHS

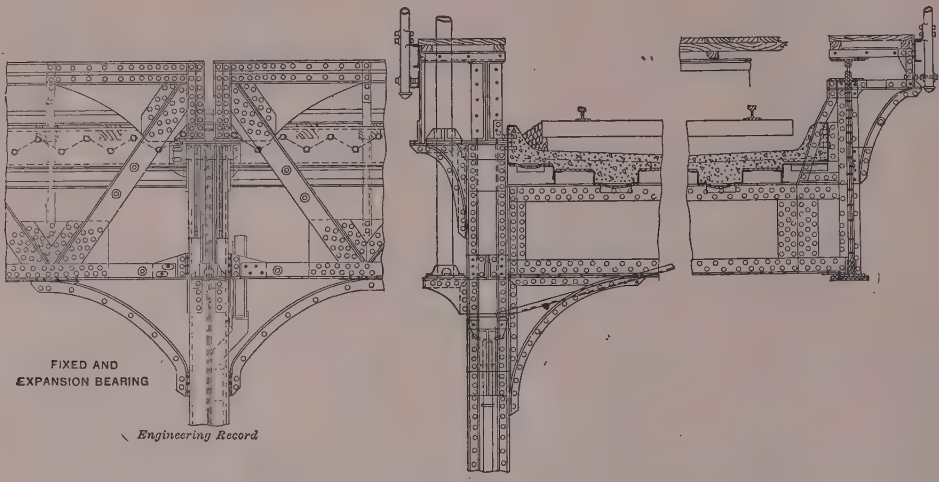
Typical Details of Plate Girder Construction.

In the typical regular construction the columns have an H-shaped cross section made with a web plate, connecting four angles, and two 15-in. channels, the flanges of the latter being turned inward with round corners. The feet of the columns have extended bases reinforced by horizontal flange angles and are seated on concrete pedestals about 20 in. below the surface of the pavement. The base of the column is enclosed in a solid mass of concrete extending nearly to the top of the pavement, where it is capped with a cast-iron fender filled with concrete. The columns continue nearly to the level of the base of rail and receive both the longitudinal and transverse girders, which are connected to them with field rivets and knee-braces.

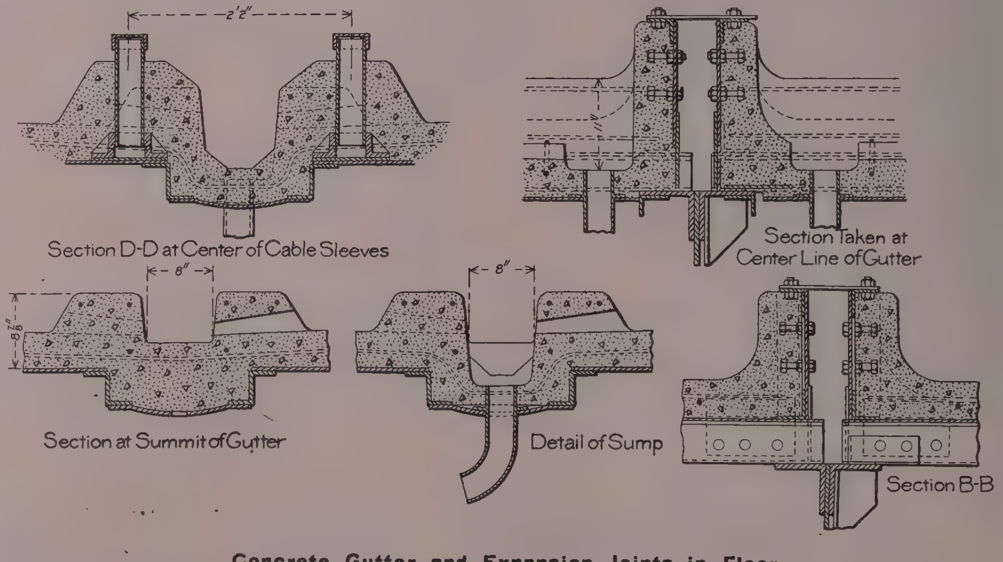
The longitudinal girders are made with their principal bearings at the top of the chords which are provided with pedestals seated on the column caps. The lower chords theoretically terminate at the first panel point away from the column, but are continued to the columns and riveted there to secure a more rigid and continuous construction. At expansion points about 200 ft. apart, the fixed trusses are riveted to the column caps and the expansion trusses are secured to them with bolts engaging slotted holes in the base plates of the pedestals. The lower chord connections to the posts are also made with bolts in slotted holes, thus permitting the truss to slide back and forth sufficiently to accommodate the temperature movements. In other places adjacent trusses are field-riveted together through the outstanding flanges of the vertical angles at their ends. The top chords of the longitudinal trusses are about 2 ft. higher than the base of rail and support the inner ends of light wooden sidewalk beams, the outer ends of which are supported by fascia channels bracketed out from the longitudinal girders.

In the regular construction the transverse girders at the column bents are substantially the same as the intermediate floor beams which are 10 ft. apart and at alternate panel points of the longitudinal girders. They differ chiefly in that the former have knee-braces on their lower flanges and the latter have them on their upper flanges. Both of them are supported by field rivets through the end vertical angles, which in one case are driven in the column flange and in the other case are driven in the flanges of the vertical posts of the trusses.

The solid floor is of special construction made with longitudinal troughs built with 5 1/16 x 3 5/16 x 3/8-in. Z-bars, having their horizontal flanges connected by 15 x 3/8-in. flat top plates and 17 x 3/8-in. dished bottom plates. The troughs were shop-riveted complete in sections about 7 ft. wide and 20 ft. long, the dished bottom plates being cut to clear the flanges of the transverse girders. The top plates of the troughs are spliced with short horizontal cover plates and at the ends of the bottom plates short angles are riveted to the edges of the transverse girder flange angles to prevent any drip from following the surface of the girder. The troughs are filled with 1:3:6 concrete made with Vulcanite Portland cement filled in to a minimum height of 4 in. above the top plates alongside of the middle longitudinal drainage gutter, from whence the surface is placed on a 3 per cent. grade to a curb, or fascia channel, which on the inner or track side is also covered with concrete, and is placed to the side of the longitudinal girder. To prevent shrinkage cracks, the concrete is reinforced with 3/8-in. Johnson bars, 12 in. apart transversely and 18 in. apart longitudinally. In order to secure the concrete and key it thoroughly to the vertical face of the fascia web and at the expansion joints where the concrete is retained by a similar cross curb or fascia, horizontal bolts are made to project a few inches from the webs of the curbs or fascia and are united by zig-zag lines of wire bedded in the concrete.



Regular Column Connections, Floor Construction and Trolley Pole Support.


2'2"
Section D-D at Center of Cable Sleeves
Section Taken at Center Line of Gutter
8"
8"
8"
Section at Summit of Gutter
Detail of Sump
Section B-B

Concrete Gutter and Expansion Joints in Floor.

The concrete is finished with 1 in. of granolithic, pitched to the gutter on the center line of of the structure, the latter having a minimum grade of 1 per cent. to drainage holes at both ends of every span. Stone ballast is filled in on the concrete surface and receives the cross ties as indicated in the detail, and the rain water, drip, etc, drains to the open gutter and thence through short vertical pipes to inclined steel troughs with their lower ends discharging into cast-iron catch basins placed inside the main vertical columns. These catch basins waste through vertical pipes carried down inside the columns to the street level, where they discharge to underground drains connected to the sewer.

In the deep span construction the longitudinal girders are made with lighter chords than those of the regular construction and the knee-braces are omitted. The transverse girders at the column bents in the deep construction are of the same depth as the longitudinal girders, and like them are light lattice girders supporting the floor troughs on their top flanges. The intermediate floor beams in the deep construction consist of latticed cross frames.

In the spans adjacent to the Schuylkill River, where the plate-girder construction is adopted, there is considerable variation on account of the deflection of the alignment and in a number of spans the longitudinal girders are supported by transverse girders projecting a considerable distance beyond them in order to provide for the location of the vertical columns at suitable points in the street, and to clear the street railway track connections. The longest transverse girder is about 53 ft. 4 in. long and is eccentrically loaded by the longitudinal girders as indicated in the accompanying diagram. It has a 72-in. web and the top and bottom flanges have sectional areas of 68.7 sq. in. gross, and 60.8 sq. in. net, respectively, being made up with 8x8x3/4-in. angles and 20-in. cover plates. The top flange is peculiar in that it also has a pair of 5x3 1/2-in. angles riveted between the first and second cover plates, stiffening the edges of the flange, as indicated in the detail. The maximum shear of this girder is 449,100 lb., requiring a net cross-section of 51.50 sq. in. of web. The maximum bending moment is 65,840,000 in.-lb., which requires a net bottom flange area of 60.4 sq. in. The dimensions and proportions of the other bents vary considerably, some of them having the longitudinal girders in the planes of the columns and some of them having one longitudinal girder supported on a cantilever extension of the transverse girder.

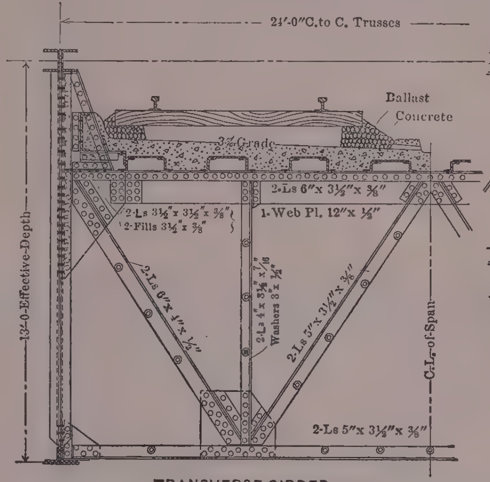
The girders were designed for unit stresses of 15,000 lb. net section in tension reduced by the compression formula, and have a shear of 9,000 lb. per sq. in. in the web plates. Rivets were proportioned for a shear of 10,000 lb. per square inch, and a bearing of 20,000 lb. per sq. in. An excess of 25 per cent. was required for field-driven rivets. Except for the rivets, which were 50,000-lb. steel, 60,000-lb. open-hearth steel was used throughout, and a variation of 5,000 lb. above or below this amount was permitted. The structure was proportioned for a live load of electric cars 46 ft. long over all, with 25,000-lb. loads on each of the four axles spaced 5.5, 2.7 and 5.5 ft. apart with provision for impact. The total weight of the main steel superstructure is about 41,000,000 lb. and that of the solid floor type is about 2,000 lb. per lin. ft.

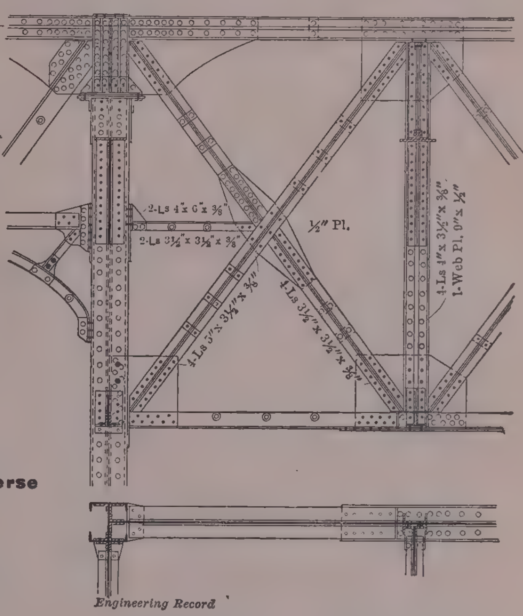
As the alignment of the tracks at the end of the elevated structure is a reversed curve, the columns supporting the plate girder spans are located so as to cause the least possible obstruction in the street. All of the eight spans of plate-girder construction are different, most of the longitudinal girders are oblique to the column bents and vary in their relative positions, some of them being attached directly to the columns and the remainder to transverse girders, some of them between the column centers and some of them outside of the columns, often making an unsymmetrical construction. In all cases they are through spans with two longitudinal girders 7 ft. deep and 28 ft. 9 in. apart, with 34-in. plate girder floor beams about 10 ft. apart, carrying on their top flanges longitudinal floor troughs made with Z-bars and horizontal top and bottom plates similar to those used in the regular lattice girder spans.

Typical arrangements are indicated by the elevations of bents 11 and 6, which show the different relative positions of the longitudinal girders. The other bents have each side similar to one side of one of these bents, sometimes both sides being like the same side of the bent here shown and sometimes one side being like a portion of one bent and the other side like a portion of the other bent. In bents 66 and 11, there are two cross-sections of longitudinal girders shown close together at one side of each bent, these representing the two girders of adjacent spans, one on one side of the transverse girder, and one on the other, there being only a single line of longitudinal girders on each side of the bent, but in these cases the girders are not coincident at their connections to the transverse girders and so make an offset here indicated by the double girders.

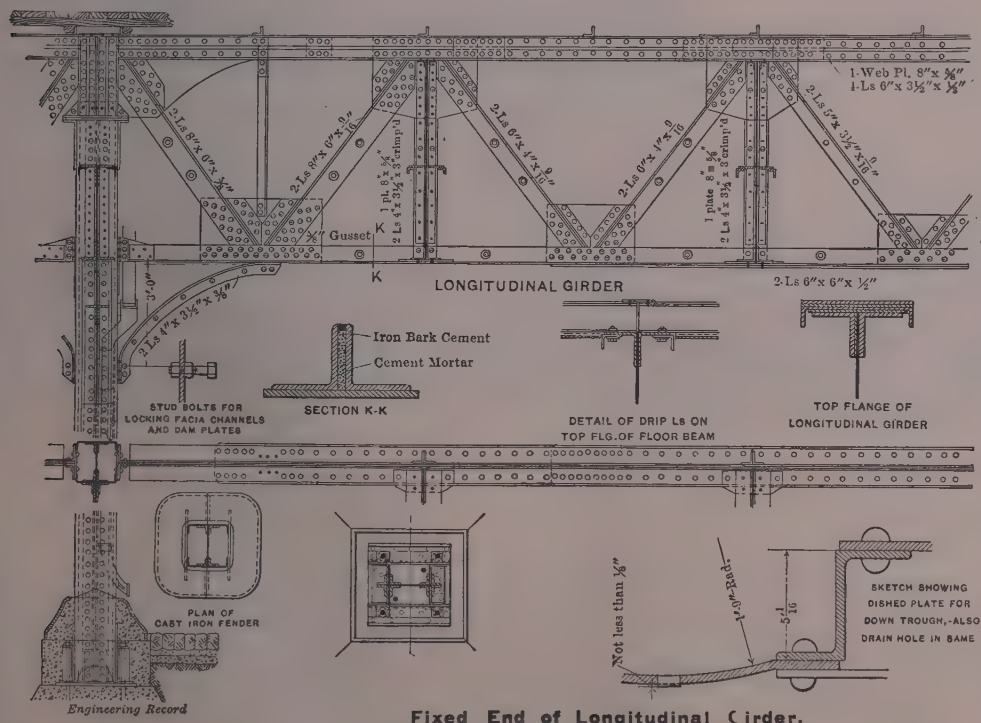
Where the longitudinal girders are connected directly to the columns they have fixed ends and the bottom flanges are cut to clear so that the ends of the girders can be inserted between the column flanges and the vertical end connection angles shop riveted to the girder web and field riveted to the column web. Where the longitudinal girder is just outside the column web, the fixed end is field riveted through vertical end connection angles to a web plate shop riveted to the column and virtually forming a bracket integral with the column web. This bracket is also substantially a continuation of the transverse girder, both girder and bracket being seated on solid-web knee braces.

The expansion end of the longitudinal girder in the same position is seated in a pocket corresponding to those provided for expansion ends connected to the transverse girder between the columns. These pockets have vertical side plates riveted to web-stiffener angles far enough apart to clear the flanges of the longitudinal girders. Between these side plates there are riveted transverse and longitudinal diaphragms making, in cross section, two adjacent rectangles one side of which is formed by the web of the transverse girder, their common side forming a diaphragm in the plane of the web of the longitudinal girder. The upper edge of this diaphragm has a pair of horizontal flange angles which form a seat for the lower flange of the longitudinal girder. The latter is free to move back and forth over it, guided by the side plates to the side of the pocket.





Connection of Longitudinal and Transverse Lattice Girders to Column.



Fixed End of Longitudinal Girder.

In all cases, the expansion end of one girder is adjacent to the fixed end of the next girder and the latter is field riveted to the floorbeam web without interfering with the expansion joint. All of the longitudinal girders have their top flanges 2 ft. 2½ in. above the top flanges of the transverse girders, and at the level of the base of rail.

The regular 50-ft. spans were most of them erected by an overhead traveler which consisted of a horizontal platform running on the top of the deck and carrying a pair of vertical masts braced together, with 40-ft. wooden booms. The work was commenced by a light traveling derrick which had a short boom with A-frame and rear stiff-leg mounted on a counterweighted truck, which set the columns in advance and sustained them until they were secured by the anchor bolts to the foundation piers which gave them sufficient temporary stability. This method was followed for a short time, until the material was received so that it could all be handled by the traveler. At 63d St., the 28-ton transverse girder was erected by a pair of gallows frames, each of which was equipped with two 6-part tackles. The girder was brought from the railway siding on a long-reach truck, blocked up out of the way until the adjacent material was received and then moved under the gallows frames, and hoisted to place. Part of the work was erected by an overhead traveler similar to the one already mentioned, but having two 65-ft. steel booms which were capable of erecting the longest longitudinal girders except at 32d St., where they were spliced out about 10 ft. to raise the 80-ft. girders. All field rivets were driven by Chicago pneumatic hammers operated by portable compressor plants moved along the line as occasion required. The work was designed and supervised by the Philadelphia Rapid Transit Co., Mr. William S. Twining, chief engineer, and Mr. Charles M. Mills, principal assistant engineer in charge of the subway and elevated railroad construction. The American Bridge Co. was the contractor for the fabrication and erection of the structural steel work which was manufactured at its Pencoyd, Ambridge and Edgemore plants.

Sale of Water-Power from the Power Company's Point of View.

A paper read before the Street Railway Association of New York, by Mr. C. E. Parsons.

There are three important factors which have to be considered in determining the cost of hydro-electric power for a railway system; the first cost of the power plant and distributing system; the amount of power to be delivered, and the load-factor. There is no reason to expect a railway manager to consider a proposition for power unless there is a saving over the cost of operation by steam, and the stumbling block in the way of a contract is usually the amount of this saving. The railway companies as a rule are not thoroughly conversant with the first cost of a plant and distributing system, and do not realize the magnitude of the interest and maintenance charges.

Before considering the sale of power from the power company's point of view, it may be of interest to describe the system of the Hudson River Electric Power Co., together with some of the more important work in connection with its high voltage transmission.

There are three water-power plants in operation, and the present plans provide for the construction of nine additional plants of capacities varying from 2,000 to 40,000 h.-p. These plants will be built as the demands for power increase. The total amount of power developed and undeveloped, owned or controlled by the company, is over 150,000 h.-p. This figure is based on the average flow of the various streams.

All auxiliary steam plant has been built at Utica, and when all the apparatus has been installed it will have a capacity of 15,000 h.-p. Another auxiliary plant of equal size will be built near the eastern end of the transmission system, and the total amount of power then available in all plants, both steam and water, will be 165,000 h.-p.

The most important plant now in operation is at Spier Falls. The construction work was begun in June, 1900, and current was put on the lines in September, 1903. This plant was described in detail in The Engineering Record for June 27, 1903. The dam is the fourth largest in the world, but will be the fifth when the Roosevelt dam in Arizona is completed. Its maximum height is 157 ft., and the total length is 1,500 ft. The power house is 80 ft. wide and 400 ft. long, and is designed for ten units; six units are in operation, and the seventh will be delivering power in September.

The wheels were started in 1903 under a temporary building, and the permanent structure has been extended as fast as new units were installed. The entire building will be completed in August, and work is now progressing on the canal and penstocks, so that by October the plant will be entirely completed and the power house ready for ten units. The eighth generator is on order, and the plans are to operate the last two machines during the eight months of high water, sending the power into the Mohawk valley. Energy for this end of the system will be supplied during the remaining four months from the Utica steam plant.

The rated capacity of the generators is 2,500 kw. each, and the water-wheels can develop 5,300 h.-p., so that an overload of 50 per cent. can be carried for short periods. Under emergency conditions the generators have been operated at 3,400 kw. on an eighteen-hour run without an unusual rise of temperature. Experience, however, seems to indicate that it is not advisable to install wheels which will develop more than a 33 per cent. overload on the generators, and all new plants will be so designed.

Under normal operating conditions the current from each generator is taken through a separate bank of transformers of the same capacity as the generator, delta connected on both the 2,000-volt and the 30,000-volt sides, but in cases of necessity the low-tension bus may be used for paralleling or for running a generator on a spare bank of transformers.

The lines leading from the 30,000-volt side of the transformers are connected through motor-operated, remote-control oil-break switches, and continue to the center clips of double-throw air break selector switches. By means of these latter switches a generator may be connected to either of the two high-tension buses. These buses are provided with sectionalizing air break switches between each of the generator connections by means of which the buses may be split up into as many sections as there are generators, thus making it possible to easily run several independent circuits. There are also in the upper bus two motor-connected oil switches for sectionalizing, by means of which the different sections of the bus may be paralleled or separated while supplying current. All the generators are paralleled on the high-tension side of the transformers.

The secondary lines from the high-tension current and potential transformers are grounded for safety; the cases are also grounded. These secondary lines and all other lines that lead to the switchboard are carried in ducts laid in a brick wall. For voltage regulation Tirrill automatic voltage regulators are used, one being connected to each of the exciters.

The station was designed for a maximum of 30,000 volts, but the oil and water-cooled transformers for No. 7 and No. 8 units will have a capacity of 5,000 kw. each, wound for either 2,000-30,000 or 2,000-60,000 volts. An addition will be built back of the present high-tension end of the building, in which will be installed the automatic 60,000-volt oil-break switches which will be connected with the Utica line.

The second plant in importance is located at Mechanicsville. This plant was built in 1897, and was acquired by the Hudson River Electric Co. in 1902. Power from this plant was sent over the transmission lines to Spier Falls during 1902 and 1903, and used for construction work. This plant was a striking example of poor design from the hydraulic standpoint. The water-wheels were in very poor condition, and on account of the contracted area for the head-water and tail-water it was impossible to get more than 75 per cent. of the rated power from the generators. During 1903 and 1904 the entire water-wheel equipment was replaced by McCormick wheels, the head race was enlarged, and the area of discharge from the wheels was greatly increased. These changes were satisfactory, and it is now possible to run the machines at their full capacity.

The Hudson River at this point is divided by an island into two channels with a combined width of about 1,200 ft. The western channel is used for the head and tail-race.

The power house extends into the river 257 ft., and is connected with the island by a concrete dam 26 ft. above the bed of the river. The main dam is built entirely of concrete; the up-stream face is vertical and the down-stream face has an ogee curve. The dam is 15 ft. in height above the river bed, 16 ft. thick at the base, and 30 ft. thick through the base and apron. The total length of the spillway between abutments is 850 ft. In the western abutment are twelve waste gates, each 4 ft. x 6 ft., motor operated.

The power house lies between the west bank and the island, and is practically a continuation of the dam.

The power house is divided into two parts by a head wall 6 ft. thick. The up-stream part contains wheel chambers for seven 1,000-h.-p. power lines of wheels for the main generators, and two sets of smaller wheels for the exciters. The down-stream portion of the power house contains the governors and electrical apparatus. The total length of the power house is 257 ft. and the total width 66 ft. The tail-race is 200 ft. wide and joins the main stream 750 ft. below the power house.

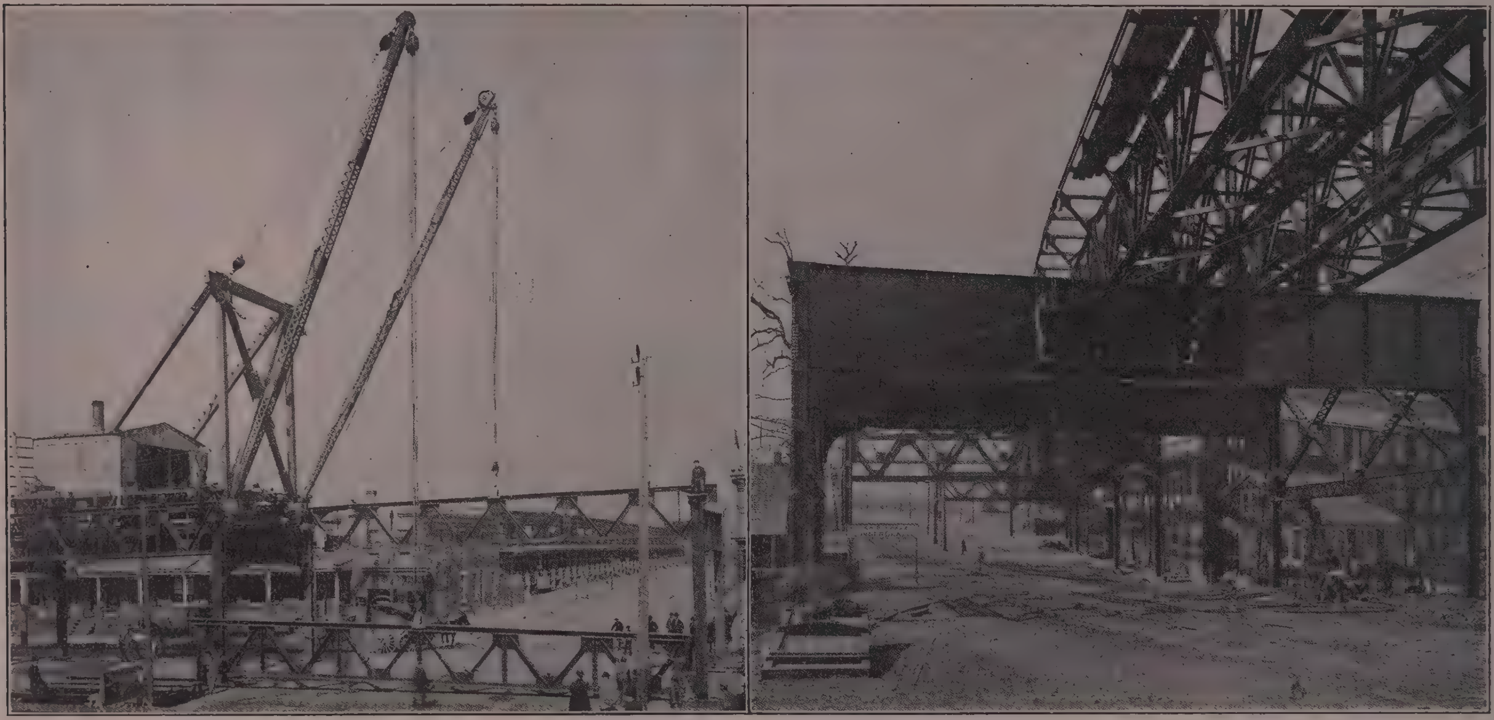
The water-wheel plant consists of fourteen pairs of 51-in. McCormick turbines. Each unit has two pairs of wheels designed to operate at a speed of 114 r.p.m., and rated at 250 h.-p.; the total power of each set of wheels is therefore 1,000 h.-p. The normal head under which the wheels operate is 17 ft.

The total generator capacity is 7,000 h.-p. in seven generators of 750 kw. capacity each. They are the General Electric type, 40-cycle, three-phase, with revolving fields and stationary armatures wound for 12,000 volts. The current is delivered to the line without the use of step-up transformers.

The switchboard along the north side of the generator room is of the latest design, and the circuits are so arranged that they can be split up and the various machines run on separate and distinct transmission lines.

An auxiliary steam plant of 1,000-h.-p. capacity was installed during the summer of 1901. This plant consists of two 505-h.-p. Heine water-tube boilers and one Hamilton Corliss tandem compound engine of about 1,000-h.-p. capacity, which can be connected by means of a rope drive to one of the water-wheel-driven, 750-kw. generators, the coupling being so arranged that the change can be made in a very few minutes.

The third water-power plant is located on the Schoharie Creek, seven miles south of Amsterdam. This plant was built in 1900 by the Empire State Power Company, and during the first three years had a checkered career. The first designs called for a masonry dam about 350 ft. long, a canal 3,500 ft. long, with 8-ft. penstocks about 200 ft. long, connecting the end of the canal with the power house.



Erecting Longitudinal Girders; Tower Bracing in Completed Structure, Market St. Elevated R. R., Philadelphia.

The plant was completed and put in operation, supplying power to the Helderberg Cement Co., at Howes Cave in 1901. During a high flood in the spring of 1901 the water cut a channel 200 ft. wide around the end of the masonry dam, and also washed away several hundred feet of the canal, completely shutting down the plant. A temporary timber dam was built to close the opening between the masonry and the south shore, and the canal was repaired. The plant was again in operation early in 1903, but during an exceptionally high flood in October the water again cut a channel around the end of the timber dam, and for financial reasons the company did not make any effort to rebuild. Control of the Empire State Power Co. was obtained by the Hudson River Electric Co. in 1904. During that summer a heavy timber spillway about 300 ft. long, and a timber dike about 400 ft. long, were built, extending from the end of the masonry dam to a high rocky bank on the south side of the stream. Four heavy floods have passed over the structure without injury, and the plant has been in continuous operation since early in 1905.

The equipment in the power house consists of two 700-kw. Stanley Indicator alternators, one 250-kw. General Electric belted alternator, and three 500-kw., 2,000-15,000-30,000-volt General Electric transformers. The machines were originally built for 60-cycle, 11,000 volts, but have been rewound for 40 cycle, 2,000 volts.

This plan is one of five which will eventually be built on the Schoharie, and when storage reservoirs have been completed, the minimum flow will produce about 12,000 h.-p. on an eighteen-hour basis.

During the past year an auxiliary steam turbine plant has been built at Utica. The total capacity of this plant will be 8,000 kw. at normal load, with sufficient boiler capacity for 50 per cent. overload, giving a total output of 15,000 h.-p. Transformers will be installed for 2,000-60,000 volts so that power can be taken from or delivered to the lines.

A change in the type of construction of the transmission lines of the company is being made. All new lines are to be of the steel-tower type, and the old lines will be rebuilt with towers as rapidly as the necessary arrangements can be made.

The change to the tower type was brought about primarily by the adoption of 60,000 volts for the line from Spier Falls to Utica. Another very strong reason for the change is the short life of the wooden poles and fixtures.

The experience of the company has been that the life of a wooden pole is from nine to twelve years, and the life of a cross-arm in many instances is even less. Within the past year cross-arms on twelve miles of pole line have been replaced at a cost of about $500 per mile. The first cost of material and labor for poles and fixtures was about $500 per mile, and the cost for repairs on cross-arms alone during eight years was equal to the first cost of poles and fixtures. This expense consisted almost entirely of labor, as the work was done at night, on Sundays, and at such other times as the current could be taken off of the line. The poles carried two circuits, and power could be off from only one circuit at a time. Some of the poles are beginning to show signs of weakness just below the surface of the ground, and are being replaced as rapidly as necessary. All of these poles were of sound chestnut and the cross-arms were of first quality Southern pine.

In order to maintain a wooden pole line in first-class condition the experience of this company has shown that maintenance and depreciation amount to 20 per cent., or that the amount of money expended in ten years is twice the first cost on the poles and cross-arms.

The cost of steel towers for two circuits and ground wire, including special construction for corners and transpositions, is about $2,500 per mile. This includes first cost of towers, freight, concrete foundations, erection, and all work except labor of putting on insulators and stringing cables.

On a comparative basis the cost of steel tower construction is five times that of the pole line. Records show that galvanized towers for windmill purposes are in perfect condition after thirty years of service, and it is therefore evident that the tower line will be the cheaper type of construction.

The cost of insulators built for the same voltage is about equal in either type of construction, but the leakage must be greatly reduced on the towers.

The effect of lightning on a steel tower line in this climate is problematical, but with the towers well grounded and with copper ground wire of large capacity it would seem as though the conditions were more favorable with towers than with the pole line.

The line from Ballston to Utica, now under construction, is being built of galvanized steel angle towers designed for two circuits, with a ground wire placed in the center of the tower three feet above the top of the conductors. The towers are all of the same general type of construction, and there are three different arrangements of cross-arms and insulators.

The standard towers, which are used on tangents and where the deflection angle is less than 20 deg., weigh 4,200 lb. each, and have an ultimate breaking strength of 8,000 lb., the pull applied at a point 50 ft. above the ground and equally distributed over the four pins of the lower cross-arm. The towers will also have an ultimate strength of 8,000 lb. in a direction normal to the pull of the main conductors. The transposition towers weigh 5,600 lb. each and stand the same strain as the standard towers. These towers are placed 2½ miles apart. The corner towers are of very much heavier construction, and weigh 10,000 lb. each, having an ultimate breaking strength of 17,000 lb. applied in either direction. These towers are only used where the deflection angle exceeds 20 deg. The same arrangement of pins is used on all angles between 20 and 90 deg.

The usual spacing of the towers is 550 ft., but the distance depends largely on the contour of the ground, some of the towers being 750 ft. apart and others not more than 400 ft. The average number of towers per mile is about ten.

All towers are arranged for a separation between wires of 6 ft. at all parts of the span, which necessitates a greater spacing between the insulators at the corner towers. The steel angles forming the upright members are built in the form of A frames, as viewed from a point normal to the direction of the line.

The view in the direction of the transmission line shows the corner angles perpendicular, with diagonal angles from the apex at one side tied to the foundation at the opposite lower corner. These angles cross at a point 25 ft. above the ground and are tied to a common gusset plate. The four angles at the top of each side near the end of the lower cross-arm are notched and clamped together with a very heavy cast-iron clamp held with four ¾-in. bolts. The main vertical and diagonal members are held with diagonal struts and tie-rods in all directions. The base of the tower is 17 ft. square.

The foundations for the standard and transposition towers are built of reinforced concrete buried five feet below the surface of the ground. The lower part of the foundation consists of a concrete slab 4 ft. square and 12 in. thick. The anchorage is a 3-in. x 3-in. x 5/16-in. angle with two cross-angles, 3 in. x 3 in. x ¼ in., riveted back to back across the bottom of the upright. The cross-angles are embedded in the concrete about 4 in. above the bottom, and ¼-in. twisted steel bars, placed 6 in. apart, are laid in both directions immediately above these angles. A concrete column 10 in. square, reinforced with ordinary chicken wire, extends from the flat concrete base to a point 8 in. above the surface of the ground, completely surrounding the vertical 3x3-in. angle. The foundations for the corner towers are 5 ft. square, and the other dimensions are the same as for the standard towers. There are, however, two upright angles, 3 x 3 x 5/16 in., at each corner of the tower, and these angles are tied together with a 2x¼-in. strap about half way between the bottom of the concrete base and the surface of the ground. All the anchorages are set with a templet to grade, and the towers are then assembled on the ground and raised and bolted to the foundation angles.

Both upper and lower cross-arms are built of 3x3x⅛-in. angles, latticed, the upper arm being 11 ft. 9 in. long, and the lower arm 17 ft. 9 in. long. For each conductor single pins are used on the standard towers, while three pins, so placed as to evenly distribute the load, are used on the corner towers.

On the transposition towers the conductor is dead-ended on two pins, thus requiring four pins in a straight line for each conductor in order to make the transpositions.

All inside pins are made of 3-in. standard pipe, and outside pins of 3-in. extra heavy pipe drawn down at the top and fitted with a 1½-in. bolt thread 2½ in. long, which engages a metal bushing in the top of the insulator. All pins have been tested with a strain of 2,000 lb. applied at a point 18 in. above the cross-arm. The pins will stand a pull of 3,000 lb. at this point without permanent deflection.

The insulators are made with four petticoats, are 15½ in. high, and the greatest diameter is 18 in. A metal bushing with 1½-in. thread is cemented in the top of the insulator. The head of the insulator is so arranged that the pull of the tie wires is applied directly in line with the metal bushing below the top of the pin. There are 2¼ in. of porcelain between the top of the pin and the conductor. The various parts of the insulator are tested to 60,000 volts, and the insulator when assembled is tested wet to 140,000 volts. The insulators before the final test are turned bottom up, filled with water and allowed to stand twelve hours in order to be sure that all parts have been thoroughly fired and glazed. The weight of the insulator is about 45 lb.

The conductors are six-strand, hemp-center copper cable, the equivalent of 000 solid wire; the outside diameter is ½ in., and the breaking strength under test is about 6,100 lb.

A ground wire of the same size and material is strung the whole length of the line. Every fourth tower is grounded by means of a galvanized iron plate, 20 x 30 in., buried in moist ground and completely surrounded by 5 in. of crushed coke.

The conductors are tied to the insulators by means of copper cable, single 0 equivalent. There are two tie cables, one to take the strain in each direction on either side of the insulator. Each tie is wrapped around the head of the insulator, and the ends are brought back and fastened to the main conductor by a specially designed malleable-iron clamp with three grooves. All of these towers were built by the Aermotor Co., of Chicago, and were erected by the construction department of the Hudson River Electric Co.

One of the largest items in the cost of a system for supplying power is the sub-station and apparatus. There are at the present time eleven sub-stations in operation, with capacities ranging from 1,000 to 10,000 kw. The total cost of the distributing system, including transmission lines and sub-stations, is about equal to the cost of the generating stations.

The second item to be considered in determining the cost of hydroelectric power is the total number of kilowatt-hours required. It is self-evident that an average load of 2,000 kw. is more to be desired than a load of 500 kw., as the fixed charges and operating expenses of the distributing system in either case are practically the same. This is not exactly true in regard to the interest on copper and distributing apparatus, but this item is small compared with the operating expense and depreciation on lines, etc.

The load-factor is the third and most important item in determining the cost of power, load-factor being the ratio of average to maximum load. It is evident that when the load-factor is near 100 per cent. all of the machinery is in operation on all parts of the system, and the transmission lines are carrying their full load; the entire investment will have an earning power, and the charges will be a minimum per kilowatt hour. This is an ideal condition, and one which cannot be realized. Nevertheless, it has to be used as a basis to work from in determining the cost with various load-factors. If a plant is built for supplying power for a railway only the cost per kilowatt-hour will be higher than where power is also supplied to factories and for lighting purposes. In a large mixed system consideration must be given to the loads which are on at a time when the railway demand is low and when the machines set aside for railway purposes can be used for partially carrying other loads. The value which is to be given to these separate loads must vary according to the character of the load and the time of year.

There are two methods which may be considered in making contracts for railway energy. One is the flat rate per horse-power per year, based on the maximum demand, the other method is on the kilowatt-hour basis. In either case a fixed amount of power as the maximum load is agreed upon, and momentary overloads of 5 or 10 per cent. are allowed.

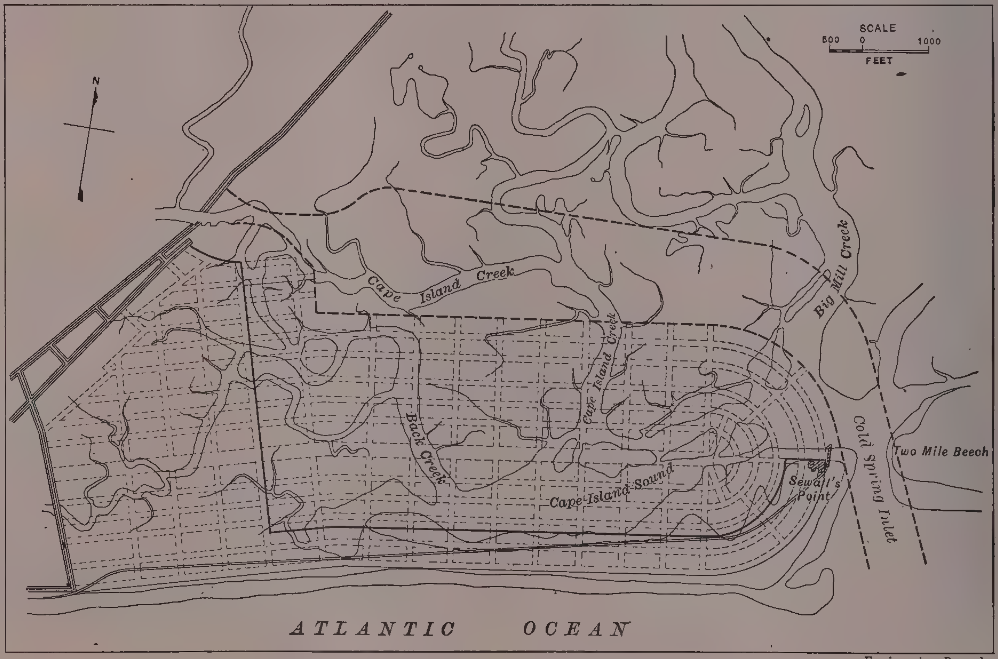
With the flat-rate method the power company is not interested in the load-factor, and the burden falls on the railway company. The only way for the railway company to take advantage of the cheaper hydroelectric power is by the use of storage batteries or by the operation of an auxiliary plant to carry peak loads.

With the second method of charging on the kilowatt-hour basis the power company must be protected by a minimum monthly payment. This minimum payment must be determined by the average load-factor. The load-factor, therefore, is the basis for determining the cost with the kilowatt-hour method.

The items to be considered in fixing the cost to the railway company per horse-power per year are the fixed charges, consisting of interest, depreciation, taxes and insurance; the cost of manufacture, consisting of labor, repairs and supplies; the cost of distribution; and the cost of management. There should then be added a reasonable dividend on the stock. The sum of these items, less the dividend, divided by the average amount of power which can be supplied at the distributing stations throughout the year, determine the cost per horse-power per year to the power company. This cost with large customers determines the price which they are to pay for energy. If, now, the power company is to be subject to the loss of income due to apparatus being idle for a part of the time, on account of low load-factor, the railway company's cost per kilowatt-hour must be correspondingly increased.

The gist of the matter is that with the flat-rate method, in order to obtain the benefit of the cheaper power, the railway company must make an investment in either a storage battery or an auxiliary power plant and bear the interest and depreciation of the same; while with the kilowatt-hour method the rate to the railway company is higher but the power company bears the interest and depreciation of the apparatus which is idle part of the time, but which must be maintained in readiness to supply the maximum demand. In the kilowatt-hour method consideration should be given to the factory and lighting loads whose peaks do not overlap the railway load. In this manner the load-factor on each individual machine is increased and the railway company derives the benefit of this greater load-factor. In other words, the railway load-factor may be 45 per cent., but by means of the loads which can be carried on the plant the average load-factor on the machines supplying the railway company, which are usually running in parallel with some of the other machines, can be built up to, say, 70 per cent. This load-factor of 70 per cent. is used instead of 45 per cent. in determining the cost of the power for the railway company.

To analyze the methods of determining the cost, a concrete example will be given. The figures used are for comparison only and do not represent conditions of operations.



Engineering Record

Areas Dredged and Filled for Cape May Improvement.

The maximum railway load is 3,000 kw., or 4000 h-p., and the load-factor is 45 per cent. Considering the fixed charges and the cost of operation, it is determined that the value of the power at the railway company's sub-station is $100 per horse-power per year. The cost to the railway company with the flat-rate method will, therefore, be $400,000 per year, or, if the full amount of power could be taken for twenty-four hours per day every day in the year, the cost would be $.0153 per kilowatt-hour. With a load-factor of 45 per cent. the average power would be 1,350 kw., or 1,800 h.-p., and the cost would therefore be, with no storage battery on the system, $.0338 per kilowatt-hour. The cost to the railway company is therefore $100 per horse-power per year, based on the maximum amount of power used, and the cost based on the average of 1,800 h.-p. used is $222 per horse-power per year. On account of the great cost per horse-power per year based on the energy actually used, the railway company is compelled to install a storage battery and decrease the maximum demand. The maximum demand will therefore be 1,350 kw., the average load, plus a battery loss of approximately 350 kw., making the maximum demand on the power company 1,700 kw., or 2,260 h.-p. The cost to the railway company for the hydroelectric power will therefore be 2,260 h.-p. times $100, or $226,000 per year. To get the total cost for power there must be added the interest and depreciation of the storage batteries, which will amount approximately, on a comparative basis, to $30,000 per year, making the total cost to the railway company $256,000.

With the kilowatt-hour method the value of the power at the distributing station is the same, or $100 per horse-power per year, or $.0153 per kilowatt-hour. Instead of using the load factor of 45 per cent. in determining the cost to the railway company, the railway company is given the benefit of the average combined load-factor of the generating plant. This load-factor is 70 per cent. and the cost to the railway company is $142 per horse-power per year for power actually used, or $.021 per kilowatt-hour. The total cost, therefore, to the railway company is 1,800 h.-p. times $142, or $255,600 per year.

The power company must have a minimum guaranteed monthly payment based on the maintenance of the load-factor by the railway company. The power company is also protected by the maximum demand which cannot be exceeded, and is assured of a stipulated income; so that if the railway company's load factor drops below whatever amount is stated in the contract, the railway company will be the loser by reason of paying for power which they have not used. Thus the railway company derives the benefit of the larger combined load-factor of the plant in determining the cost per kilowatt-hour, but is obligated, by reason of the minimum payment, to keep its load-factor within reasonable limits.

It is evident that the actual cost in either case is approximately the same, but with the flat-rate method the railway company has to make a larger investment in order to take advantage of the hydroelectric power.

A 150-Ton Tower Crane, with a balanced pivoted bridge having an overhang of 80 ft., is in operation in the harbor of Dublin, Ireland. The tower is 80 ft. in height and the bridge about 130 ft. in length, the trolley having a range of lift of 100 ft.

The Cape May Improvements.

Important construction is now under way which is planned to create a large and valuable extension to the summer resort town of Cape May, N. J., to extend and improve an existing beach, to reclaim many hundred acres of marsh land and to provide a deep inner harbor. The scheme is supported largely by Pittsburg capital, and in being conducted by the Cape May Real Estate Co., which has made plans for an addition to the present area of the town by means of an easterly extension of about two miles along the shore of the Atlantic Ocean to Sewell's Point, where there is now merely a summer excursion house at the extremity of a low and narrow beach. This extension will be approximately rectangular and about one mile in width, with the eastern extremity rounded.

The area comprised by it was originally a salt marsh with the surface at about high-tide level and covered by numerous creeks and inlets affording channels for shallow tidal streams. The ground was entirely useless in its former condition and the long beach which bordered the ocean side was not well suited for pleasure purposes. The marsh is to be filled entirely with material dredged from the inner harbor on the north side and will be built up 11 ft. above high tide in the center, graded down to about 6 ft. at the beach. It will be laid out in streets and avenues provided with city improvements. A wide boulevard will extend from end to end near the center line and will be lined with rows of trees, along the shore side a beach road and broad elevated board walk have already been built, and at a central point the foundations have been constructed for a large steel frame summer hotel that is expected to be finished for the present season.

At the end of the improvement the existing Cold Spring inlet separating it from Two Mile Beach will be deepened, and it is hoped that the United States Government will provide an appropriation for the construction of jetties there which will enable the tidal flow from the inner harbor to excavate and maintain a sufficient depth to provide a ship channel from the 30-ft. contour, about half a mile out, so that the inner harbor may serve as a refuge which is needed at this point of the coast. It is estimated that the improvement will require about 15,000,000 cu. yd. of fill which will cost $1,500,000, and that the expenditure of as much more money will be required for other features of the real estate improvement exclusive of the buildings and other investments to be made in the development of the pleasure resort.

Dredging was commenced in November, 1904, and several hundred acres of the fill have been completed at the west end of the work adjacent to the old town. The requirements of the contract provided for the fill to be first made in an approximately triangular area squaring up the end of the old town to an approximately north and south line and extending its water front more than four blocks on the south side, and also along a strip about two blocks wide from this point the full length of the ocean front before the fill behind or north of it was made completing the peninsula which is to be constructed.

The space enclosed by the harbor and inlet lines varies from about 1,000 to 2,000 ft. in width and has a total length of nearly three miles. Before dredging was commenced the surface was just covered with water except in the narrow, crooked channels where the depth seldom exceeded 12 ft. The bottom consisted of about 10 ft. of mud over a fine sand. This is to be excavated to a minimum depth of 30 ft. and all of the spoil used for fill, care being taken to deposit the mud first and cover it with the clean sand from a lower level thus following the natural sequence of operations.

The contract for dredging and filling 10,000,000 yd. was secured for the Atlantic Gulf & Pacific Co., by its late president, Mr. George W. Catt. The company has now in operation on the work the 30-in. centrifugal dredge Pittsburg, the 20-in. centrifugal dredge Washington, and the 24-in. centrifugal dredge, George W. Catt, has recently been installed. The first mentioned dredge had been operated on this work by other owners for some months before operations were begun by the present contractors. They acquired this dredge and by means of essential modifications soon succeeded in doubling its efficiency.

The first part of the work was done under considerable disadvantage owing to the fact that the first material filled required the longest transportation so that the records are not indicative of maximum capacities. The results, however, are considered remarkably successful under the circumstances. The 30-in. dredge has pumped 150,000 yd. of sea sand in one month through 8,000 ft. of pipe with a 10-ft. lift which is believed to excell all previous records for sea sand. The 20-in. dredge has pumped 273,000 yd. of sand in one month through a pipe 2,000 ft. long with a 10-ft. lift.

All of the sand dredged is first loosened by a revolving conical cutter head operated at the inlet of the suction pipe. Owing to the depth of dredging the machines have the advantage of being able to work for a considerable time in a single position. They can thus often continue uninterruptedly for several hours or a day or two, swinging back and forth from the anchor spud without redriving the latter. The discharge pipes are floated both on ordinary pontoons and on catamaran pontoons. Those from the smaller dredges have rubber sleeve joints, but these are so difficult to maintain on the large pipe that its joints of maximum motion are made with various special arrangements of ball joints, swivel elbows, etc., all of which are devised by the contractors. The location and movement of the dredges is not by any fixed plan except that care is always exercised to handle them so as to begin work as near as possible to the fill and always to keep them in such a position as to reduce to the utmost the length of discharge pipe.

So far the work has been done with an average length of discharge of about 5,000 ft., but it is hoped that by the completion of the work this length will have been reduced to about 3,500 ft. When the three dredges are in full operation they will require a total force of about 70 men in each of the two 12-hr. shifts by which operations are continuously maintained day and night.

The dredged material is confined on the reclaimed area by means of levees thrown up by hand labor. The lower part of the levee is built with the mud and grass excavated from the surface of the marsh, and the top is made by filling out with the sand deposited by the dredge as it gradually rises inside the levee. The top width is about 3 ft., and the slopes are the natural angle of the material which is about 1:1, the height reaches a maximum of 10 ft. on the side nearest the old town. This construction is rapidly and cheaply made with a minimum labor expense, and is efficient in retaining the suspended material while the water drains off. It is required that the contract shall be completed June 1, 1907, and progress is now about two months ahead of the schedule.

Mr. Peter Shields is the president, and Mr. E. D. Thompson, New York, is the consulting engineer for the Cape May Real Estate Co. Another contract for driving and filling on this work has been awarded to the Furst-Clark Dredging Co., which is also now at work in the inner harbor.

The New Water Power Plant of the Blackstone Manufacturing Co.

A water power plant has recently been erected on the Blackstone River by the Blackstone Manufacturing Co., for the operation of its extensive cotton mills in the town of North Smithfield, R. I., just across the Massachusetts State line. The Blackstone River is well known in southern New England for the succession of moderate sized water powers which it affords in its course of 50 miles between its source in Worcester county and its discharge into tidewater at Providence. The total fall of the river in its course is about 600 ft., and its discharge varies from 2,000 to 3,000 cu. ft. per second at a point about 10 miles above its mouth. The majority of water power developments along this river have been of a purely hydro-mechanical character, without the use of electrical transmission, but the Blackstone Manufacturing Co.'s plant is a notable exception.

The Blackstone Mfg. Co. is one of the oldest organizations in the valley, cotton manufacturing having been begun by it at Blackstone, Mass., in 1808. The original mill was supplemented in later years by four other mills and the five were operated together for nearly half a century by water and steam power in combination. On account of excessive taxation of the mill property by the town of Blackstone in recent years, however, the managers of the plant, Messrs. Goddard Bros., Providence, R. I., decided to erect a new mill across the State line in North Smithfield, R. I., together with a new power plant which would use the same water supply as the old mill, but which should be equipped for the electrical transmission of power to the new mill machinery.

The new mill contains 40,000 spindles, and is a structure of three stories and basement, 366 ft. long by 130 ft. wide. On the east end is a picker house, 100 x 67 ft. in plan, two stories and basement high, the latter being used as a dust room. At the west end is a weave shed 89 x 130 ft. in plan, composed of one story and a full story basement. Both wings are built to carry additional stories in the future to the full height of the mill if desired, and the total frontage of the mill as now existing is 522 ft., with a depth of 130 ft. for most of this distance. A stair tower 30 ft. square projects from the front of the mill near the center, which carries in the fourth story, a 6,000-gal. tank for artesian well water for drinking supply and general mill service, and in the top story a 60,000 gal. steel tank for fire protection. The foundations of the mill are all of concrete resting almost entirely upon ledges. The walls, above the finished grade, are built of dark red Barrington bricks laid in red mortar, with granite window and door sills, and heavy granite underpinning throughout. For the floor high-grade plank and timber were used with an intermediate floor and a maple surface. While the old mills contained 5,000 more spindles than the new one, the modern equipment of the new mill permits of a considerably increased production. The new mill contains four sets of pickers, 72 sets of cards, and 1,032 looms. Its output is about 50,000 lb. of cloth per week for sheetings and fine goods, necessitating the employment of about 350 hands.

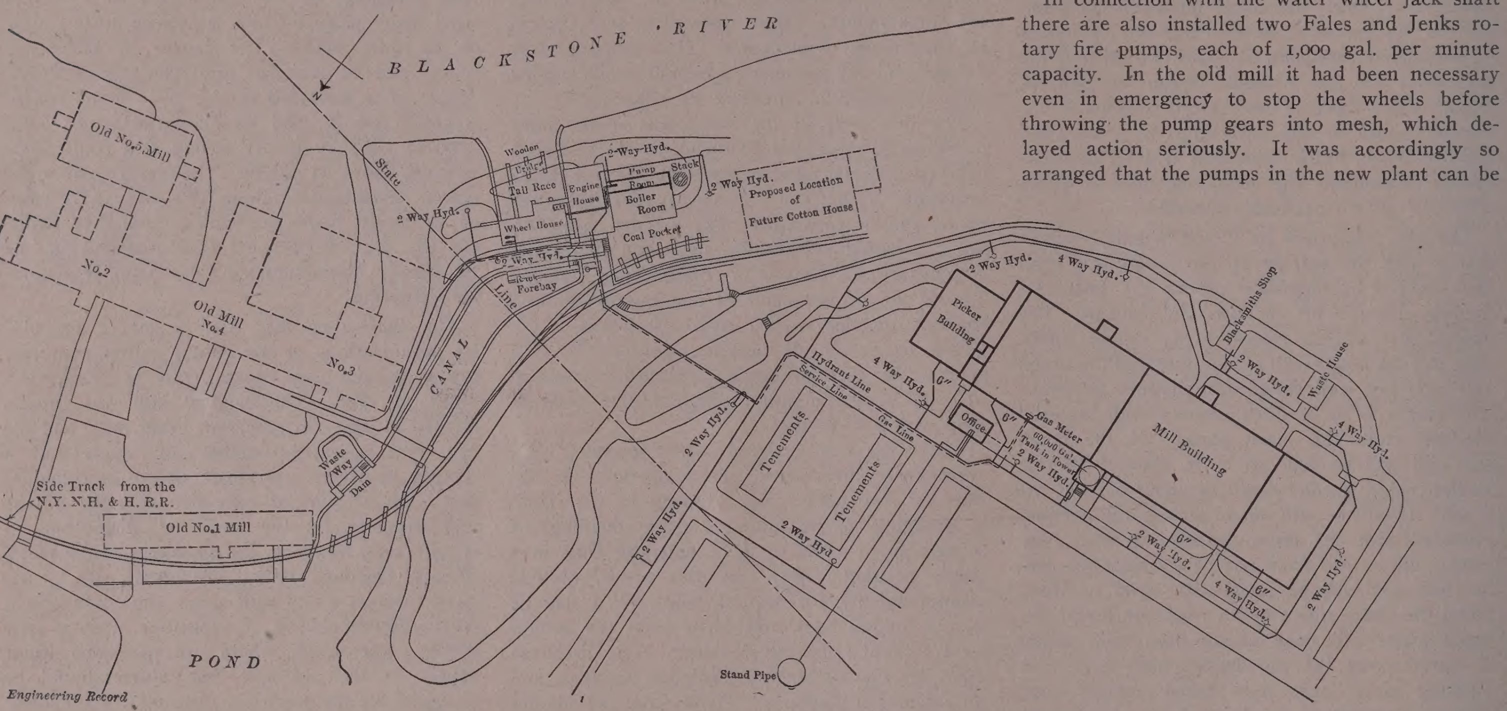
For the water power development, a masonry dam was built across the river at a point about three-quarters of a mile above the new mill site, and a large storage pond thus created. The entire discharge of the river is turned from this pond through the old Providence and Worcester Canal, which it follows for about half a mile to a small pond which served as a forebay for the old No. 1 mill. This mill was originally driven by two wheels 30 ft. in diameter, but with the completion of the new mill about 18 months ago, the old mill buildings and works were razed to the ground. From the small pond the water is conducted to the forebay of the new power house through a canal about 500 ft. in length which has concrete walls 14 ft. high, increasing to a height of 20 ft. At the forebay the average width of the canal is 40 ft. and the depth of water 8 ft. The concrete was laid in the winter season by Mr. John P. Morris, the materials being heated and the walls protected against the severe cold to prevent damage by frost. The canal terminates about 30 ft. over the State line and the water is then conveyed directly to the turbines, of which there are four 36-in. Hercules machines with vertical shafts. The arrangement of the canal is such that the full fall is secured, whatever the variation in head at high water may be, insuring thus a permanence of power which was not available under the old arrangement, with which considerable head was often lost at high water.

The new power plant comprises a one story and basement wheel house, 80 ft. long by 28 ft. wide, an annex to this for pumps, exciters and other apparatus and connecting directly with the wheel house, a one-story and basement engine house 95 x 78 ft. in plan, and a boiler house, 50 x 72 ft. in plan, of one high story with a monitor. The buildings are of brick with concrete foundations and flat roofs carried on steel trusses, in each division except the wheelhouse. The engine and boiler rooms are separated by a 16-in. brick wall and a wall of similar thickness separates the engine from the wheel room. The different parts of the plant are readily accessible from the engine room in the center.

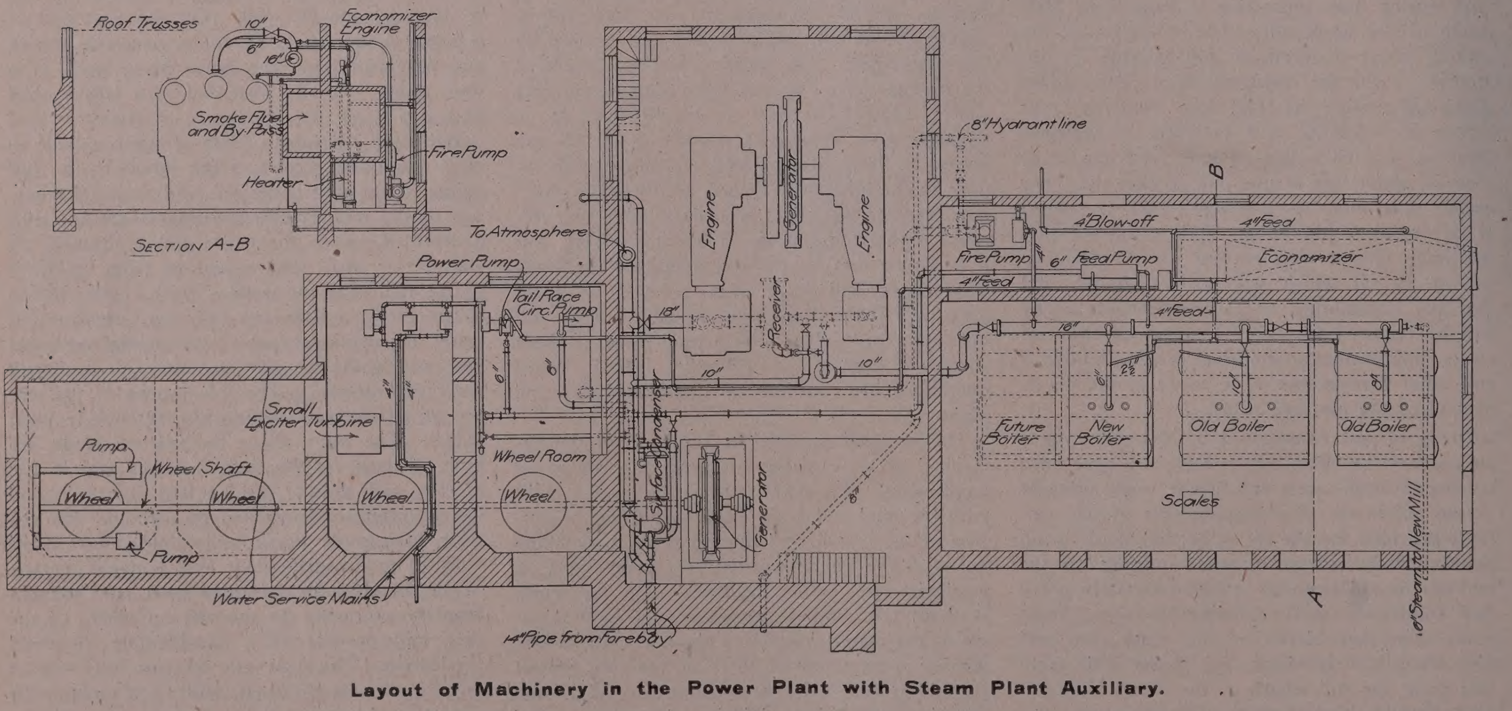
The wheel equipment consists of four vertical turbines, each rated at 375 h.p., under the head of 32 ft. They are arranged to drive through bevel gearing to a single horizontal jack shaft turning at 200 r.p.m., which is so located that one end projects into the engine room. Upon this end of the shaft is mounted the revolving field of an 840-kw., 60-cycle, three-phase, 440-volt alternating generator. The entire discharge of the river yields from 700 to 1,600 h.-p. for the operation of this machine. The wheels, which were built by the Holyoke Machine Co., of Worcester, Mass., are fitted with shaft clutches so that one, or more may be dropped out of service as the water supply necessitates, the total equipment being thus arranged to take care of the maximum flow of the stream.

In connection with the water wheel jack shaft there are also installed two Fales and Jenks rotary fire pumps, each of 1,000 gal. per minute capacity. In the old mill it had been necessary even in emergency to stop the wheels before throwing the pump gears into mesh, which delayed action seriously. It was accordingly so arranged that the pumps in the new plant can be immediately started by a friction clutch drive from turbine shaft and by this means the immediate delivery of four 1⅛-in. streams at 100 lb. pressure per square inch is possible in case of an emergency. The turbine driven pumps are supplemented by a 1,000-gal. 18 x 10 x 12-in. duplex Underwriters' steam fire pump located in the boiler room.

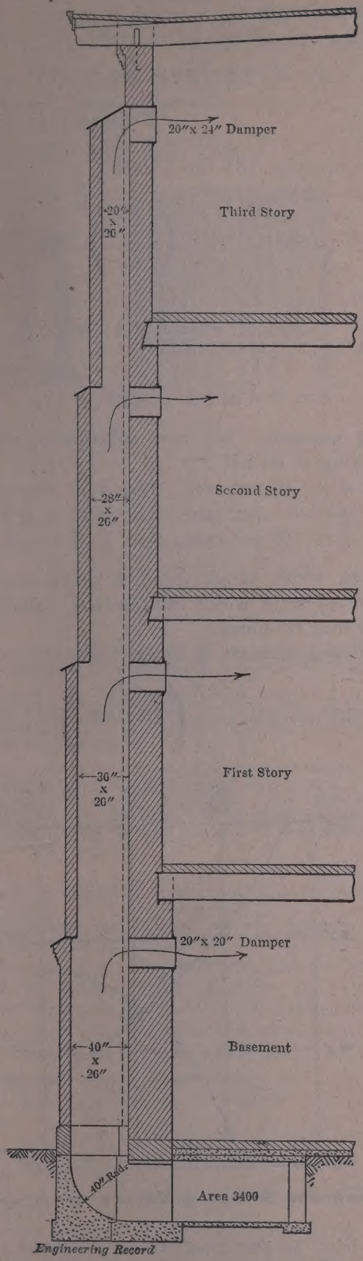
This water power is supplemented by a steam plant consisting of three Stirling boilers of 920 h.p. rated capacity and a 24 and 48 by 24-inch Filer and Stowell horizontal cross-compound con-



Ground Plan of the Blackstone Mills and Water Power Development.



Layout of Machinery in the Power Plant with Steam Plant Auxiliary.



Details of Heating Flues.

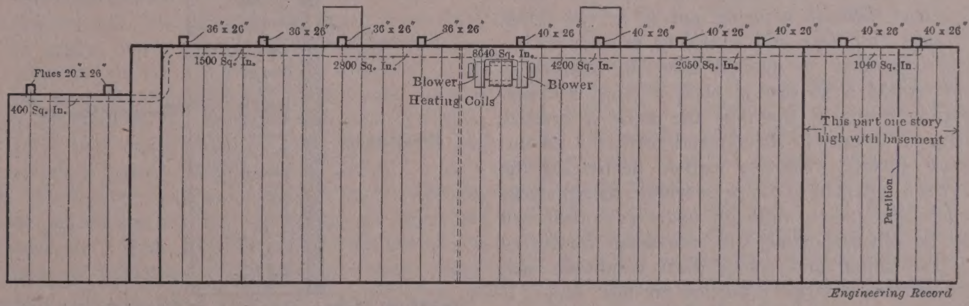
densing engine direct-connected to a 750-kw. alternating current generator. The engine operates normally at 90 r.p.m. and is designed for operation with a steam pressure of 125 lb. and a vacuum of 25 in. The condenser serving the engine is a Wainwright surface condenser of 1,000 h.p. rated capacity, and is located in the engine room basement.

The engine-driven generator is also of the revolving field type and like the other, is wound to deliver three-phase current at 440 volts and 60 cycles. Exciting current for this and also the other generator is furnished by two belt-driven exciters of 22.5 kw. capacity each, which deliver 125 volts direct current. These are operated at 600 r.p.m. from a countershaft driven from the main turbine jack shaft. An auxiliary connection is also provided so that this counter shaft may be driven from an old 20-in. Victor turbine which was re-set for this purpose, in case of emergency.

For the boiler plant, two of the Stirling boilers were re-set from the old mill, and a new 750 h.p. boiler of similar make added, making three boilers in all, with space available for a fourth unit when extension of plant becomes necessary. The boilers are set in substantial settings of brick with hand-fired grates, there being a 13-ft. firing floor in front and the breeching connections at the rear. From the boilers the gases of combustion pass to a Green fuel economizer, which is equipped with a 4½ x 8-ft. by-pass to the chimney. The stack is 165 ft. high, with an inside diameter of 6½ ft. In the economizer the temperature of the flue gases is lowered to about 235 deg. Fahr. at light loads and to 285 deg. Fahr. at heavy loads. In spite of these low temperatures in the gases no mechanical draft is employed. The draft is controlled by a Locke automatic damper regulator. Feed water is drawn from the river by a Knowles auxiliary 8 x 5 x 10-in. feed pump, by a Hancock injector for emergency service, or by a Davis quadruplex power driven 6 x 6½-in. feed pump. The latter pump is used in regular service. There is also installed at the rear of the boiler room a Warren 6 x 6 x 12-in. single pump for the supply of drinking water for the mill and tenement house supply system.

Pocohontas lump and slack coal is fed to the boilers by hand, and storage for this is had just outside the power house in the direction of the mill, the first floor of which is 65 ft. above the engine room floor level, as the mill is located on a high bank considerably above the river. Coal is at present brought to the plant by team, but a side track from the New York, New Haven & Hartford R. R. under construction will permit it to be delivered direct from cars to the coal pocket.

The power plant switchboard is composed of four standard panels, two for the main generators, one for the exciter and the other for the distribution circuits. Each generator has a recording wattmeter, besides the usual equipment of indicating instruments, phase lamps and synchroscope, so that the output of the water power and the steam driven unit may be recorded separately. From the power house, current is delivered to the mill for lighting and power by an overhead line composed of three three-phase circuits of bare copper carried on poles. The length of this line is about 400 ft. Two of the circuits are for power service, the remaining one being for lighting supply. All the wires in the line are of 1,000,000 c.m. section.



Arrangement of Heating Apparatus in the Mill Building.

The steam piping system consists of a 16-in. header in the boiler room with 6, 8 and 10-in. supply branches from the boilers and branches to the steam using machinery. Two branch lines supply the feed and fire pumps, and a 6-in. steam main runs to the mill through a pipe conduit consisting of a wooden box supported by concrete piers placed 15 ft. apart on centers. The steam header is connected at the engine room end of the boiler room to a 10-in. main in the engine room basement, which supplies the engine through a separator located beneath the high pressure cylinder. Between the high and low pressure cylinders is an intermediate receiver, which is fitted with a reducing valve and a 6-in. by-pass connection so that the engine can be operated from the low pressure side alone if desired. The 10-in. exhaust line from the high pressure cylinder to the intermediate receiver, has an alternative connection, so that if desired, the intermediate receiver and low pressure cylinder can be by-passed directly into the condenser or outboard exhaust main. The intermediate receiver is connected with the low pressure cylinder by a 16-in. line, and the low pressure cylinder thence exhausts into an 18-in. main to the surface condenser which is fitted with a back-pressure valve and atmospheric exhaust.

The circulating water for the condenser is drawn by gravity from the forebay through a 14-in. pipe, into which is tapped an 8-in. line for a cold water pump supply. The condenser overflow pipe is 10 in. in diameter, and the condenser discharge passes to the tail race. It is so connected that the boiler feed pumps can draw their supply from it, any excess of water being discharged into the waste pipe through a 10-in. line connected beyond the condenser. The feed pumps and fire pump are also so connected as to permit them to draw water from the tail race.

The mill building is heated on the indirect system, the general arrangement of which system is shown in accompanying drawings. The heating coils and fans are located near the center of the west basement wall and the warm air is delivered to a number of vertical brick distributing flues by a horizontal concrete duct running beneath the basement floor along the entire course of this wall. The heating coils are located practically at the center of the duct which has a cross sectional area of 8,640 square inches opposite the coils. The coils consist of a bank of about 12,000 ft. of 1-in. pipe and the air is forced through the system by two 10½-ft. Sturtevant fans, each direct-connected to a 10 x 12-in. engine. The typical vertical distributing flue starts from the basement with a 40 x 26-in. section decreasing to a 20 x 26-in. section on the third story. The openings from these for the supply of each floor are 20-in. square in sectional area with the exception of the third story opening, which has 20 x 24-in. dampers. The bottoms of the damper openings are located 10 ft. above the floor level for downward distribution. The fan engines are supplied by 3-in. steam lines connecting with a 6-in. main supply, 2½-in. steam pipes being used for the coil supply. The fan engine exhaust pipes are 3½ in. in diameter with 2½-in. coil exhausts. The system is equipped with the American humidifyer for the automatic regulation of the humidity of the air delivered.

All of the power wiring in the mill is of the open type. The motors are all supplied with 440-volt 3-phase current, while the lamps are operated at 110-volts single-phase, three lighting transformers being located outside the mill on the wall nearest the end of the transmission line for the single-phase distribution. The wiring contractor was the Lord Electric Co., of Boston. The motor equipment consists entirely of Westinghouse induction motors which are installed in sizes from 50 to 150 h.-p.

In the process of manufacture, on the first floor of the mill the raw stock is opened by four openers in the picker room, which are driven in a group by a 15-h.-p. motor. The stock is then carried to the next floor by pneumatic power in tubes leading to four breaker, four intermediate and four finisher pickers; these 12 machines are driven in a single group by a 75-h.-p. motor. In the next room on the second floor are 36 cards, 30 deliveries of drawing and a slubber, driven by a 75-h.-p. motor; and 36 cards, 6 slubbers and 101 deliveries of drawing run by another 75-h.-p. motor. A fourth 75-h.-p. motor drives 10 fine speeders and second intermediates, 10 jack speeders and 2 slashers, while a 50-h.-p. motor drives 15 fine speeders and second intermediates, and 5 jack speeders. All the above machines except the slashers belong to the carding department.

The spinning room is located on the third floor. Here 40,000 filling spindles are operated by two 150-h.-p. motors, one of which in addition runs a freight elevator at one end of the spinning room. There are 16,416 warp spindles run by two 150-h.-p. motors, and also a 75-h.-p. motor drives 3,584 warp spindles, 1,680 spoolers, 14 warpers, 1 twister and a second freight elevator. The weaving room is located on the first floor and partly in the basement. The looms are 1,032 in number, of the 40-in. Northrup type. Two 50-h.-p. motors drive 190 looms each; one 75-h.-p. motor operates 282 looms and some light repair shop machinery; one 75-h.-p. motor runs 170 looms, a triplex power pump and compressor for the humidifying system, and the remaining 200 looms are run by a 75-h.-p. motor, which also runs the light machinery of the cloth inspecting room.

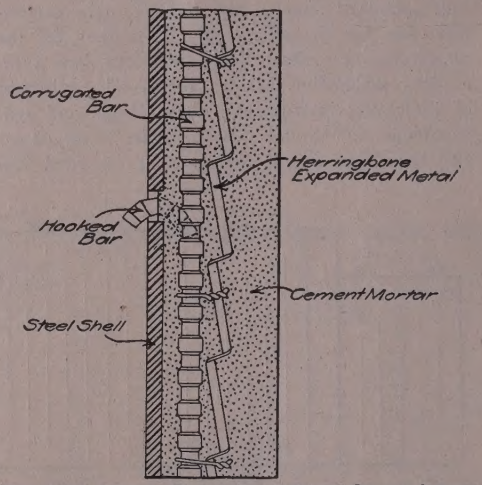
Mr. Ansel Holman is the electrician of the plant and the superintendent is Mr. George E. Spofford. The engineers for the installation were Messrs. Lockwood, Greene & Co.

Letters to the Editor.

Cement Mortar Linings for Steel Stacks.

Sir: One of the many new uses to which Portland Cement is being put is in the lining of steel chimneys and stacks to prevent or arrest corrosion. A method especially adapted to new stacks is to cast in place a thick, self-supporting lining at the time the stack is erected, using a collapsible sheet metal form for the interior surface. Another method devised by the writer is adapted to the preservation of old stacks where the metal, although badly corroded, will yet be self-supporting and safe when reinforced by the lining, and where draft conditions will not permit a large reduction in flue area. It seems to be well demonstrated that a lining of cement and sand will effectually prevent or arrest corrosion, and will also withstand temperatures usually found in stacks serving boiler furnaces. The stacks which were lined in this manner were 68 in. inside diameter before lining and 110 ft. high, being made of No. 8 steel. They have been in service a number of years and were badly corroded from the boiler house roof up to the tops. The corrosion increased from the roof line to the top, where the metal was more than half gone, and the seams open. Below the boiler house roof there was no corrosion whatever, so that about 35 ft. of each stack inside the house was as good as new. Each stack serves two 350-h.-p. boilers which are worked under their full rating 24 hr. per day. The stacks were of ample size; in fact, the boilers were generally run with the stack dampers partly closed to check the draft. The installation includes a number of stacks of this size which would cost about $600 apiece to take down and rebuild in the same manner as before, and it could not be expected that their life would exceed five years. Two of them have been lined so far at an expense of $225 each, and after some months of use, the lining appears to be in perfect condition. The illustration herewith shows a vertical cross section of the lining, which consists of Portland cement mortar reinforced with ¼-in. corrugated steel bars placed vertically and spaced about 20 in. apart around the stack, with No. 24 gauge herringbone expanded metal lath wired to the rods, as shown.

The lining was carried up from the base of the stacks. The first operation was to drill a series of holes about 20 in. apart and about 5½ ft. from the base of the stack. Into these holes were hooked a series of corrugated bars as shown. These bars were cut about 5½ ft. long, and were bent into a short hook at one end. A second series of holes about 5 ft. above the first series was then drilled and a second set of bars inserted. Where the vertical bars lapped, they were wired together and the metal lath was then firmly secured to them and plastered. The mortar, composed of one part cement to 2½ parts sand was thoroughly worked into the lath and back of the bars, and finished to a thickness of 1¼ to 1½ in. A center pole was built of 2 x 4-in. timbers, double, and a sliding scaffold rigged on it. Stays were nailed to the pole below the scaffold as it was advanced, and the operations of hanging bars, securing lath and plastering, repeated. In each case, from 15 to 30 ft. of the upper portion of the stacks was removed entirely, leaving them 85 and 100 ft. high, respectively. The lining was kept moist for a week or ten days before putting into service, and as before stated, has shown no defects. It is interesting to note that, although both height and flue area had been decreased, there was still an abundance of draft. The stacks are also much cooler to the touch, and the paint does not burn off as heretofore. Particular attention was paid to the guying and thorough repairs made to the fastenings in order as they were reached.



Vertical Cross-Section of Steel Stack Lined with Portland Cement Mortar.

Very truly yours,

Thos. Griswold, Jr.

Midland, Mich., July 24, 1906.

A Formula for Reinforced Concrete.

Sirs: Below will be found a correction to the formula for reinforced concrete derived by me and published in The Engineering Record for July 7. Mr. I. P. Church, in a letter published in your issue of July 21, pointed out the error in my assumptions and I desire to thank him for calling attention to the matter. The error was due to the assumption that the moment of tension in the steel about the neutral axis is equal to the compression in the concrete about the same axis.

If the reasoning given in my letter of July 6 will be followed as published until the value of S is obtained in equation (6) no error will be made.

Now from Fig. 2 having S, the following analysis may be made:

$$Sa - \frac{ch}{2} = 0. \qquad (7)$$

Substitute value for S found in equation (6) and equation (7) becomes

$$\frac{2 \times a \times (d-h)\, c}{h} \, \frac{E_s}{E_c} = ch. \qquad (8)$$

Solve equation (8) for h then

$$h = \pm \sqrt{2ad\frac{E_s}{E_c} + a^2\left(\frac{E_s}{E_c}\right)^2} - a\frac{E_s}{E_c} \qquad (9)$$

If $\frac{E_s}{E_c} = 12$, then equation (9) becomes

$$h = \pm \sqrt{24\,a\,d + 144\,a^2} - 12\,a \qquad (10)$$

Using equation (10) and substituting different values for a, we get

when $a =$ ½ per cent., then $h = 0.29\,d$,
$a = 1$ per cent., then $h = 0.37\,d$,
$a = 1½$ per cent., then $h = 0.43\,d$.

Using above values for h, a curve may easily be plotted from which intermediate values for a and h may be found.

Resisting moment of beam:

$$M = \frac{c \times b \times h}{2}\left(d - \frac{1}{3}h\right) \qquad (11)$$

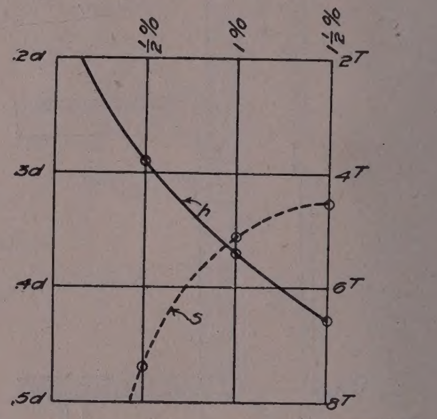


Diagram Showing Values of H and S.

For ½ per cent., $M = 0.139\,bcd^2$;
For 1 per cent., $M = 0.162\,bcd^2$;
For 1½ per cent., $M = 0.184\,bcd^2$.

Very truly yours,

W. W. Pearse.

New York, July 24, 1906.

Another Alpine Tunnel is to be built at once in connection with a new railroad which will pass through the Bernese Alps and connect at Brig with the Simplon tunnel. This new railroad will have a total length of 56 kilometers, of which 13½ kilometers will be in one tunnel. It will be operated entirely by electricity and will have a maximum gradient of 0.27 per cent. The new road will serve as the most direct means of communication between northern Italy, including Milan and Genoa, and the districts to the north and northwest of Switzerland. It will also shorten the approach to the Simplon, which is now reached via Lausanne, and will compete with the Gotthard tunnel railroad. From an international standpoint Paris will be 15 miles nearer the cities of Italy through the new tunnel than via the new Lausanne-Simplon tunnel route and about 100 miles nearer than via the Gotthard. In addition to its value as an international trunk line the new road is expected to be of great commercial importance to central Switzerland, particularly to the Canton and city of Berne, by affording a direct route to the south, without necessitating a detour to the Gotthard tunnel on the east or via Lausanne on the west to the Simplon.